SOIL SURVEY OF

Butler County, Kansas

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Kansas Agricultural Experiment Station

Issued January 1975

Major fieldwork for this soil survey was done in the period 1956–68. Soil names and descriptions were approved in 1969. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1969. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Butler County Soil Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Butler County are shown on the detailed map at the back of this survey. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in this publication. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the range site, woodland group, and windbreak group in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and ranchers and those who work with them can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units, range sites, woodland groups, and windbreak groups.

Foresters and others can refer to the section "Use of Soils as Woodland and for Windbreaks," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife habitat in the section "Use of the Soils for Wildlife."

Ranchers and others can find, under "Range Management," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Community planners and others can read about soil properties that affect the choice of sites for recreation areas in the section "Soil Interpretations for Recreational Uses."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that describe soil properties that affect engineering and show the relative suitability of the soils for specified engineering purposes.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Butler County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "Additional Facts About the County."

Cover: **Smooth brome grazed by beef cattle on an Irwin silty clay loam.**

Contents

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SOIL SURVEY OF BUTLER COUNTY, KANSAS

BY HAROLD L. PENNER, SYLVESTER C. EKART, DONALD A. EWING, GORDON SCHMIDT, AND JIMMIE SMITH, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE KANSAS AGRICULTURAL EXPERIMENT STATION

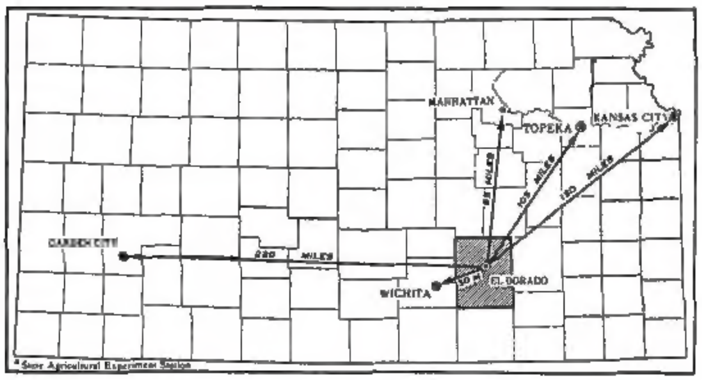

Figure 1.—**Location of Butler County in Kansas.**

BUTLER COUNTY, the largest county in the State, is located in the southeast part of Kansas (fig. 1). The total area is 1,443 square miles, or 923,520 acres. The population was 38,395 in 1960. In that year El Dorado, the county seat, had a population of 12,523. In Butler County about 280,000 acres are used for field crops, 538,000 acres are used for range, 27,000 acres are used for pasture, and 18,500 acres are used as woodland. The rest is in roads, water areas, and built-up areas.

Farming, ranching, and industry all play a vital role in the economy of the county. Corn and sorghum for silage, alfalfa, grain sorghum, bromegrass, and fescue are grown and are largely used as feed for livestock. Cash-grain farming is also part of the farming economy. The principal cash-grain crops are wheat and soybeans.

The raising of beef cattle is the major enterprise in this county. Both the production of calves and the fattening of steers are important. The feeding of beef cattle is practiced extensively throughout the county, and farm feedlots are common in the northwestern part. One commercial feedlot has been established near Potwin.

Oil was discovered in Butler County in 1915. Since that time, the county has been among the leading oil-producing areas in the State. Four oil refineries are operated in this county.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Butler County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* (*10*)[1] are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Dwight and Irwin, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Norge silt loam, 1 to 3 percent slopes, is one of several phases within the Norge series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in

[1] Italic numbers in parenthesis refer to Literature Cited, p. 58.

planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. One such kind of mapping unit, the soil complex, is shown on the soil map of Butler County.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. An example is Clime-Sogn complex, 3 to 15 percent slopes.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Borrow pits is a land type in Butler County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Butler County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The eight soil associations in Butler County are discussed in the following pages.

1. Goessel-Rosehill Association

Nearly level and gently sloping, deep and moderately deep soils that have a silty clay surface layer and subsoil; on uplands

This association consists of soils on uplands that are dissected in places by intermittent streams. The soils formed in a mantle of clay sediment that is underlain by alkaline shale.

This association occupies about 4 percent of the county. Goessel soils make up about 44 percent of the association; Rosehill soils, about 41 percent; and minor soils, about 15 percent.

Goessel soils are nearly level and moderately well drained. They have a surface layer of very dark gray silty clay about 18 inches thick. The next layer, about 26 inches thick, is light olive-brown, very firm silty clay that contains common slickensides. It is underlain by grayish-brown silty clay.

Rosehill soils are gently sloping and well drained. They have a surface layer of dark-gray silty clay about 9 inches thick. The next layer, which is about 18 inches thick, is dark grayish-brown, firm silty clay in the upper part and dark grayish-brown and olive, firm silty clay in the lower part. It is underlain by grayish-brown shaly clay.

Minor soils are in the Irwin and Ladysmith series.

Most of the farms in this association are used to grow cultivated crops, mainly wheat, sorghum, alfalfa, and soybeans. A few small areas are in range. Most of the ranges are in poor to fair condition because the areas are used as holding pens, and grazing is allowed throughout the year. Water erosion is a hazard on the gently sloping soils. Soil blowing is a hazard where fields are left bare in winter.

2. Irwin-Ladysmith Association

Nearly level to sloping, deep soils that have a silty clay loam surface layer and a silty clay subsoil; on uplands

This association is on broad upland divides that are dissected in places by intermittent streams. The soils formed in clayey sediment that grades to shale in some places. Slopes are mainly about 2 percent, but some are as much as 5 percent. Irwin soils are generally more sloping than Ladysmith soils.

This association occupies about 31 percent of the county. Irwin soils, make up about 80 percent of the association;

Ladysmith soils, about 10 percent; and minor soils, 10 percent.

Irwin soils are moderately well drained or well drained. They have a surface layer of dark-gray silty clay loam about 11 inches thick. The subsoil is about 30 inches thick. It is firm, dark-grayish brown silty clay in the upper part and firm, brown silty clay in the lower part. It is underlain by reddish-brown silty clay that grades to clayey shale below a depth of 60 inches.

Ladysmith soils are moderately well drained to somewhat poorly drained. They have a surface layer of dark-gray silty clay loam about 8 inches thick. The subsoil, which is about 30 inches thick, is very firm, very dark grayish-brown silty clay in the upper part and very firm, dark grayish-brown silty clay in the lower part. It is underlain by yellowish-red and grayish-brown light silty clay and by clay that is mostly red.

The minor soils are in the Dwight, Labette, and Verdigris series. Dwight and Labette soils are in areas where the soil is less than 40 inches thick over limestone or shale. Verdigris soils are adjacent to streams.

Small grains are grown and beef cattle are raised on most farms in this association. About 40 percent of the acreage of this association is cultivated, and the rest is used for range. The soils are eroded in some of the cropped areas.

3. Verdigris-Brewer-Norge Association

Nearly level to sloping, deep soils that have a silt loam or silty clay loam surface layer and a silty clay loam or silty clay subsoil; on flood plains and terraces

This association is in the major stream valleys. About two-thirds of the association consists of nearly level soils on the valley floor, and these are subject to flooding. The rest of the association consists of sloping soils on the sides of the valley. In a few areas, sloping soils are eroded. The soils of this association formed in alluvium of different ages and in colluvium from nearby areas. Loess may have contributed to the surface layer in some places.

This association occupies about 18 percent of the county. Verdigris soils make up about 50 percent of the association; Brewer soils, about 10 percent; Norge soils, about 10 percent; and minor soils, about 30 percent.

Verdigris soils are moderately well drained. The upper part of their surface layer is dark grayish-brown silt loam about 8 inches thick, and the lower part is friable, dark-gray silty clay loam about 25 inches thick. The next layer, about 24 inches thick, is friable, very dark grayish-brown silty clay loam that has common, fine, distinct mottles.

Brewer soils are moderately well drained. They have a dark-gray silty clay loam surface layer about 14 inches thick. The subsoil, about 27 inches thick, is firm, very dark gray heavy silty clay loam in the upper 7 inches and very firm, dark-gray silty clay below. The lower part has common dark-brown mottles. The underlying material is dark-gray silty clay that has dark-brown mottles.

The Norge soils are well drained. They are on high terraces of stream valleys. They have a dark-brown heavy silt loam surface layer about 9 inches thick. The upper 9 inches of the subsoil is friable, reddish-brown silty clay loam. The next 24 inches is firm, reddish-brown silty clay loam, and the lower 30 inches is yellowish-red silty clay loam.

Minor soils are in the Vanoss, Tully, Irwin, and Osage series. Vanoss and Irwin soils are in areas similar to those occupied by the Norge soils. Tully soils are most commonly in the upper reaches of major drainageways. Osage soils are on flood plains and are poorly drained.

Except for areas of Verdigris soils that are frequently flooded, most of the acreage of this association is cultivated. The soils that are farmed are suited to all the crops commonly grown in the county.

4. Dwight-Labette Association

Nearly level to sloping, moderately deep soils that have a silt loam or silty clay loam surface layer and a silty clay subsoil; on uplands

This association is on broad, smooth upland divides that are dissected in places by intermittent streams. The soils of this association formed over limestone or shale. In about 38 percent of the area, the Dwight and Labette soils are so intermingled that they are mapped as a complex.

This association occupies about 26 percent of the county. Dwight and Labette soils each make up about 40 percent of the association, and minor soils make up the remaining 20 percent.

Dwight soils have a surface layer of dark-gray silt loam about 5 inches thick. The subsoil is about 28 inches thick and is very firm, dark-brown silty clay. It is underlain by limestone, cherty limestone, or shale.

Labette soils have a dark grayish-brown, silty clay loam surface layer about 13 inches thick. The subsoil is about 25 inches thick. The upper 5 inches is firm, dark-brown light silty clay. The next 13 inches is firm, yellowish-red silty clay; and the lower 7 inches is firm, yelowish-red heavy silty clay loam. The subsoil is underlain by limestone, cherty limestone, or shale.

Minor soils in this association are Irwin and Sogn soils. Sogn soils are on the steeper parts of the landscape, and Irwin soils occupy higher positions where the soil mantle is thicker than 40 inches.

About two-thirds of the association is in range that is used for the production of beef cattle. The rest is used for growing field crops, mainly wheat and grain sorghum. Water erosion is a hazard on the sloping soils that are cultivated. During seasons of low rainfall, droughtiness is a hazard to crops that mature in summer.

5. Labette-Sogn Association

Gently sloping to sloping, moderately deep soils that have a silty clay loam surface layer and a silty clay subsoil, and shallow soils that are silty clay loam throughout; on uplands

This association consists of gently sloping to sloping soils on uplands. Most of the soils formed over limestone, but some of the Labette soils formed over shale (fig. 2). Sinkholes are numerous.

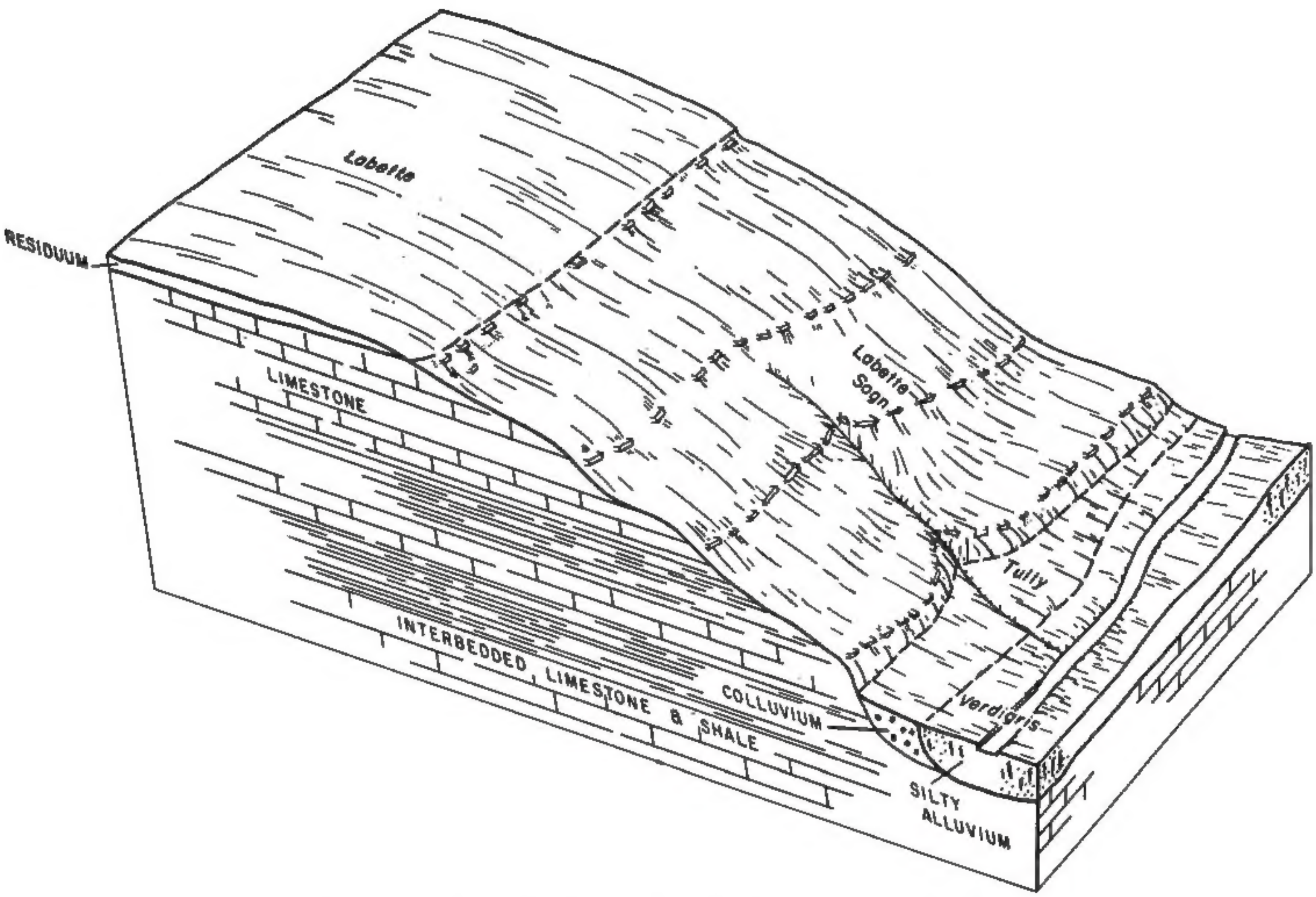

***Figure 2.*—Soils of association 5 and their position on the landscape.**

This association occupies about 5 percent of the county. Labette soils make up about 50 percent of the association; Sogn soils, about 30 percent; minor soils, 10 percent; and limestone outcrops, 10 percent.

Labette soils have a surface layer of dark grayish-brown silty clay loam about 13 inches thick. The subsoil is about 25 inches thick. In the upper 5 inches it is firm, dark-brown light silty clay. The next 13 inches is firm, yellowish-red silty clay; and in the lower 7 inches is firm, yellowish-red heavy silty clay loam. The subsoil is underlain by limestone, cherty limestone, or shale.

Sogn soils have a surface layer of very friable, very dark gray silty clay loam about 7 inches thick. The surface layer rests directly on hard limestone.

Minor soils in this association are in the Dwight, Tully, and Verdigris series. Dwight soils are in small areas and are intermingled with Labette soils. Tully soils are on the lower parts of the landscape. Verdigris soils are along drainageways.

Many oilfields are in this association. Much of the acreage is used for range. Good grazing management helps to keep the range in good condition.

6. Florence-Benfield Association

Gently sloping to strongly sloping, moderately deep and deep soils that have a cherty silty clay loam or cherty silt loam surface layer and a cherty silty clay or cherty clay subsoil; on uplands

This association is in an area called the "Flint Hills." The soils are mostly gently sloping to strongly sloping, but small narrow areas on ridgetops are nearly level. These soils formed over cherty limestone, limestone, and shale.

This association occupies about 9 percent of the county. Florence soils make up about 65 percent of the association; Benfield soils, 20 percent; and minor soils, the remaining 15 percent.

Florence soils have a surface layer of very dark gray cherty silt loam about 14 inches thick. The subsoil, about 31 inches thick, is very firm, dark reddish-brown cherty silty clay in the upper part and very firm, dark reddish-brown coarse cherty clay in the lower part. It is underlain by cherty limestone that has a few cracks filled with red clay.

Benfield soils have a surface layer of very dark gray

cherty silty clay loam about 9 inches thick. The subsoil, which is about 18 inches thick, is very firm, dark gray cherty silty clay in the upper part; very firm, dark-brown, cherty silty clay in the middle part; and light olive-brown silty clay in the lower part. The subsoil is underlain by light olive-brown silty clay. Below this material, at a depth of 35 inches, is calcareous shale.

Minor soils are in the Labette and Tully series. Labette soils are on some of the narrow, gently sloping ridgetops; and Tully soils are adjacent to some of the drainageways and in colluvium at the base of some slopes.

Beef cattle are raised on nearly all the farms in this association, and practically all of the acreage is used for native range. A few small fields were formerly cultivated, but most of them have reverted to range. This association is a grass-producing area, but good grazing management is required to keep the range in good condition.

7. Clime-Sogn Association

Gently sloping to strongly sloping, moderately deep soils that have a silty clay surface layer and subsoil, and shallow soils that are silty clay loam throughout; on uplands

This association consists of soils that formed over limestone and calcareous shale. Most of the soils are sloping; but some of them on ridgetops are gently sloping, and others adjacent to drainageways are strongly sloping and stony.

This association occupies about 3 percent of the county. Clime and Sogn soils each make up about 40 percent of the association, and minor soils and shale outcrops make up the remaining 20 percent.

Clime soils have a surface layer of very dark gray silty clay about 9 inches thick. The next layer, about 17 inches thick, is very firm, light olive-brown silty clay. Below this layer is very firm, pale-olive silty clay that is underlain by calcareous clayey shale.

Sogn soils have a surface layer of very friable, very dark gray silty clay loam about 7 inches thick. This layer rests directly on hard limestone.

Making up 10 percent of the minor soils are soils that have a profile similar to that of Sogn soils, but they are underlain by soft calcareous shale. The Labette and Dwight soils make up 5 percent of the minor soils. They are on some of the narrow ridgetops in the more level parts of the landscape. Tully soils and limestone and shale outcrops make up the remaining 5 percent. Tully soils are in colluvial material at the base of some slopes, and limestone and shale outcrops are in small areas on the points of ridges and the sides of some ridges.

Beef cattle are raised on most farms in this association, and nearly all the acreage is used for range. Good grazing management helps to keep the range in good condition.

8. Norge-Ladysmith Association

Nearly level to sloping, deep soils that have a silt loam or silty clay loam surface layer and a silty clay loam or silty clay subsoil; on uplands and terraces

This association consists of soils on uplands and terraces above and mostly adjacent to flood plains of the major streams in the county (fig. 3). The soils formed in loamy and clayey sediment. Norge soils are sloping and Ladysmith soils are nearly level. Both are in areas above the flood plains.

This association occupies about 4 percent of the county. Norge soils make up about 55 percent of the association; Ladysmith soils, 35 percent; and minor soils, the remaining 10 percent.

Norge soils have a surface layer of dark-brown heavy silt loam about 9 inches thick. The subsoil is about 63 inches thick. The upper 9 inches is friable, reddish-brown silty clay loam. The next 24 inches is firm, reddish-brown silty clay loam; and the lower 30 inches is firm, yellowish-red silty clay loam.

Ladysmith soils have a surface layer of dark-gray silty clay loam about 8 inches thick. The subsoil, about 30 inches thick, is very firm, very dark grayish-brown silty clay in the upper part and very firm, dark grayish-brown silty clay in the lower part. It is underlain by light silty clay that has mixed colors of yellowish red and grayish brown and by clay that is mostly dark red.

Minor soils are in the Brewer, Irwin, Olpe, Vanoss, and Verdigris series.

Most of this association is intensively farmed to wheat, alfalfa, sorghum, and soybeans. Water erosion is a hazard on the soils on terrace breaks and on the gently sloping and sloping soils.

Descriptions of the Soils

In this section the soils of Butler County are described in detail. The procedure is to describe first the soil series and then the mapping units, or kinds of soil, in that series. Thus, to get full information on any one mapping unit, it is necessary to read both the description of that unit and the description of the soil series to which the unit belongs.

Each soil series description contains a short narrative description of a profile considered representative of the series, and a much more detailed description of the same profile that scientists, engineers, and others can use in making highly technical interpretations. The colors described are for dry soil, unless otherwise noted.

Following the name of each unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit are the capability unit, range site, woodland suitability group, and windbreak suitability group in which the mapping unit has been placed. The pages on which each of these groups is described are given in the "Guide to Mapping Units" at the back of this survey.

Some of the terms used in the soil descriptions are defined in the Glossary, and some are defined in the section "How This Survey Was Made." The approximate acreage and proportionate extent of each soil mapped are shown in table 1.

Benfield Series

This series consists of moderately deep, gently sloping to strongly sloping, well-drained soils on uplands. These

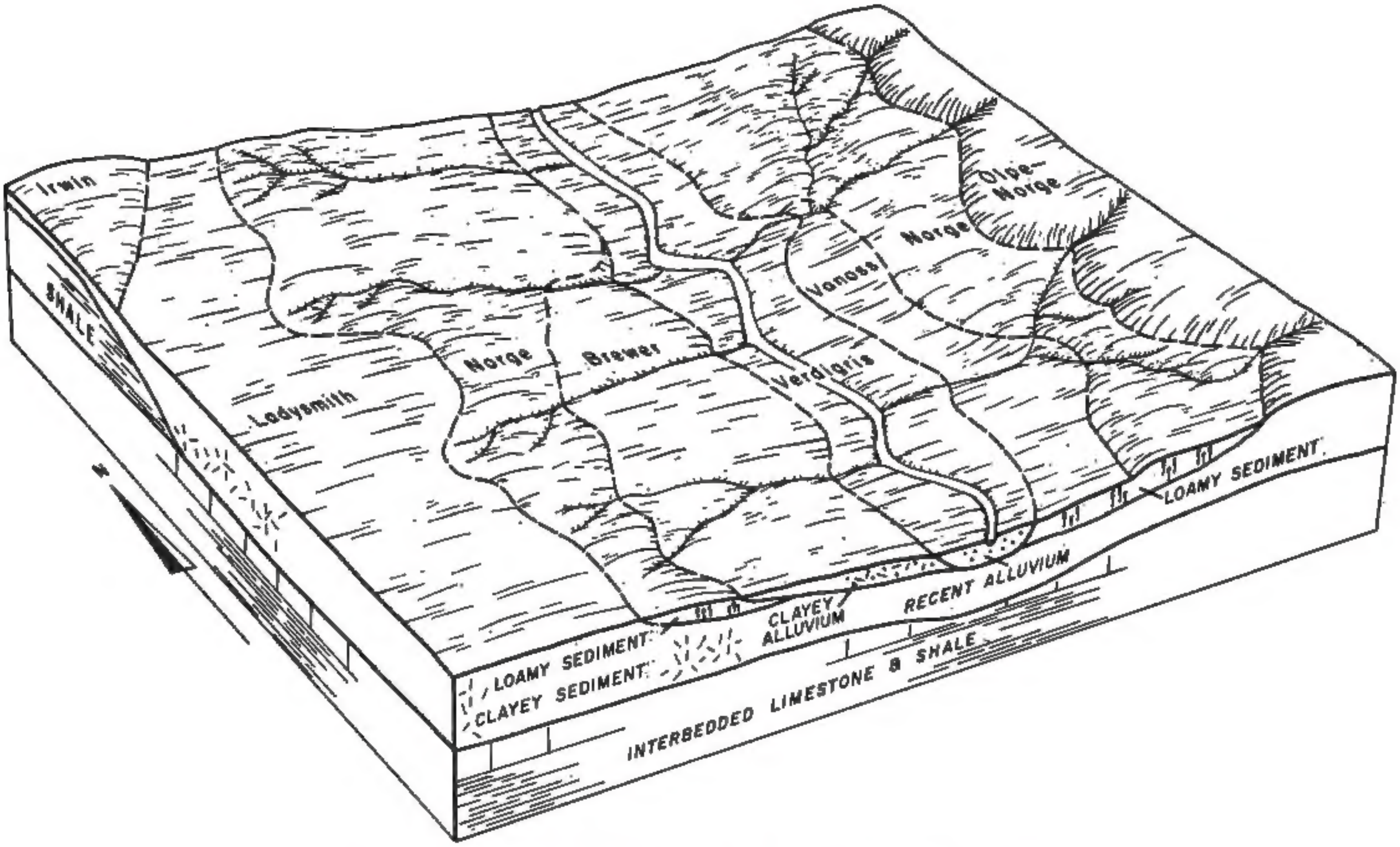

Figure 3.—**Soils of association 8 and their position on the landscape.**

soils formed in material weathered from alkaline and calcareous shale.

In a representative profile the surface layer is very dark gray, cherty silty clay loam about 9 inches thick. The subsoil is about 18 inches thick. The upper part is dark-gray, very firm cherty silty clay; the middle part is dark-brown, very firm cherty silty clay; and the lower part is light olive-brown, very firm silty clay. Below the subsoil is light olive-brown silty clay that is underlain by calcareous shale at a depth of about 35 inches.

Benfield soils have low to moderate available water capacity and slow permeability.

Representative profile of a Benfield cherty silty clay loam from an area of Benfield-Labette cherty silty clay loams, 2 to 12 percent slopes, in native rangeland, about 2,640 feet north and 300 feet east of the southwest corner of sec. 20, T. 25 S., R. 8 E.:

A1—0 to 9 inches, very dark gray (10YR 3/1) cherty silty clay loam, black (10YR 2/1) when moist; strong, medium, granular structure; hard when dry, friable when moist; 15 percent of horizon is chert fragments; slightly acid; gradual, smooth boundary.

B1—9 to 16 inches, dark-gray (10YR 4/1) cherty silty clay, very dark gray (10YR 3/1) when moist; strong, fine and very fine, subangular blocky structure; very hard when dry, very firm when moist; thin and continuous clay films; about 25 percent of horizon is chert fragments; slightly acid; gradual, smooth boundary.

B2t—16 to 23 inches, dark-brown (10YR 4/3) cherty silty clay, dark brown (10YR 4/3) when moist; moderate, medium, blocky structure; extremely hard when dry, very firm when moist; continuous clay films; few worm casts; few small, black concretions; about 30 percent of soil mass is chert fragments; slightly acid; gradual, smooth boundary.

B3—23 to 27 inches, light olive-brown (2.5Y 5/4) silty clay, olive brown (2.5Y 4/4) when moist; moderate, fine, blocky structure; very hard when dry, very firm when moist; few lime concretions; chert free; mildly alkaline; gradual, smooth boundary.

C—27 to 35 inches, light olive-brown (2.5Y 5/4) silty clay, olive brown (2.5Y 4/4) when moist; massive; very hard when dry, firm when moist; many shale chips and nests of lime; few black concretions; some peds have a darkened, very dark grayish-brown (10YR 3/2) coating; moderately alkaline; clear, smooth boundary.

R—35 inches, light olive-brown, platy shale of silty clay texture; calcareous.

The A1 horizon is cherty silty clay loam or silty clay loam, and it ranges from 7 to 12 inches in thickness. Color ranges from very dark gray to very dark grayish brown. The B1 horizon is cherty silty clay, cherty silty clay loam, or silty clay, and it ranges from 4 to 7 inches in thickness. Range in color is the same as that of the A1 horizon. The B2t horizon is cherty silty clay or silty clay, and it ranges from 5 to 15 inches in thickness. Its color is dark grayish brown to olive. The B3 horizon is silty clay or heavy silty clay loam, and it ranges from 4 to 6 inches in thickness. Colors in the B3 horizon reflect the color of the underlying shale and range from reddish brown to olive. The C horizon is silty clay or heavy silty clay loam 0 to 8 inches thick. Colors of the C horizon are the same as those of the B3 horizon, and they also reflect the color of the underlying shale. Reaction above the B3 horizon ranges from slightly acid to mildly alkaline. The B3

TABLE 1.—*Approximate acreage and proportionate extent of soils*

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Benfield-Labette cherty silty clay loams, 2 to 12 percent slopes	30, 665	3. 3	Norge silt loam, 0 to 1 percent slopes	3, 100	. 3
Borrow pits	752	(1)	Norge silt loam, 1 to 3 percent slopes	21, 592	2. 3
Brewer silty clay loam	20, 906	2. 3	Norge silt loam, 3 to 5 percent slopes	4, 692	. 5
Clime-Sogn complex, 3 to 15 percent slopes	28, 148	3. 1	Norge silty clay loam, 3 to 5 percent slopes, eroded	4, 232	. 5
Dwight silt loam, 0 to 2 percent slopes	99, 411	10. 8	Oil-waste land	1, 213	. 1
Dwight soils, 1 to 2 percent slopes, eroded	4, 123	. 4	Olpe-Norge complex, 2 to 7 percent slopes	8, 274	. 9
Florence cherty silt loam, 5 to 10 percent slopes	54, 256	6. 0	Osage silty clay	1, 767	. 2
Goessel silty clay, 0 to 1 percent slopes	6, 660	. 7	Rosehill silty clay, 1 to 3 percent slopes	14, 828	1. 6
Goessel silty clay, 1 to 3 percent slopes	10, 520	1. 1	Sogn soils	8, 264	. 9
Irwin silty clay loam, 0 to 1 percent slopes	8, 490	. 9	Tully silty clay loam, 1 to 4 percent slopes	2, 837	. 3
Irwin silty clay loam, 1 to 3 percent slopes	206, 871	22. 4	Tully silty clay loam, 3 to 6 percent slopes, eroded	1, 252	. 1
Irwin silty clay loam, 3 to 5 percent slopes	12, 040	1. 3	Tully silty clay loam, 4 to 7 percent slopes	6, 902	. 7
Irwin silty clay loam, 2 to 5 percent slopes, eroded	18, 465	2. 0	Vanoss silt loam, 0 to 1 percent slopes	4, 006	. 4
Labette silty clay loam, 1 to 3 percent slopes	37, 519	4. 1	Vanoss silt loam, 1 to 3 percent slopes	10, 426	1. 1
Labette silty clay loam, 1 to 3 percent slopes, eroded	1, 422	. 2	Verdigris silt loam	60, 065	6. 5
Labette silty clay loam, 3 to 5 percent slopes	7, 482	. 8	Verdigris soils, frequently flooded	31, 796	3. 4
Labette-Dwight complex, 1 to 3 percent slopes	91, 823	10. 0	Water	9, 846	1. 2
Labette-Sogn complex, 2 to 8 percent slopes	47, 747	5. 2	Quarries	706	(1)
Ladysmith silty clay loam, 0 to 2 percent slopes	40, 422	4. 4	Total	923, 520	100. 0

[1] Less than 0.1 percent.

and C horizons contain free carbonates, and reaction in those horizons is mildly alkaline to moderately alkaline. In most places the R horizon is calcareous shale, but the shale is noncalcareous in some places. Depth to the R horizon ranges from 20 to 40 inches.

Benfield soils are associated with Florence and Labette soils, and they have a similar profile. Benfield soils have a B2t horizon that is less red than that of Florence and Labette soils, and they are shallower and less cherty than Florence soils.

Benfield-Labette cherty silty clay loams, 2 to 12 percent slopes (Be).—This complex consists of about 60 percent Benfield cherty silty clay loam, 20 percent Labette cherty silty clay loam, and 20 percent minor soils. The Benfield soil has stronger slopes and is at a lower elevation than Labette. The Labette soil occupies narrow areas on ridgetops and on the upper side slopes. The profile of the Benfield soil is similar to the one described as representative of its series, except that the surface layer is free of chert in about 20 percent of the acreage. The profile of the Labette soil is similar to that described as representative of its series, except that from 15 to 35 percent of the soil material throughout the profile is fragments of chert.

Of the minor soils, 10 percent is Sogn soils, and 10 percent is Clime silty clay and Dwight silt loam.

Runoff is medium to rapid, depending on the steepness of the slope. Erosion is a hazard where the cover of grass is thin or where cattle trails have become gullies.

The soils of this complex are used only for range. Capability unit VIe–2; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group F.

Borrow Pits

Borrow pits (0 to 15 percent slopes) (Bp) consist of areas where soil material has been excavated and used as fill material, mainly for roads. The areas range from 10 to 140 acres in size. They are on uplands and on bottom lands. Most of the areas are excavated to a depth of more than 4 feet, and in many places the excavations have been made to the depth of limestone or shale bedrock. In areas on bottom land, the upper part of the soil profile has been removed during excavation and the less fertile underlying material is exposed. Some of the areas on bottom lands are farmed; but low fertility, frequent flooding, and ponding are hazardous to crops.

A typical area of Borrow pits is located in the southwestern quarter of sec. 4, T. 26 S., R. 5 E. Not placed in a capability unit, range site, woodland suitability group, or windbreak suitability group.

Brewer Series

This series consists of deep, nearly level, moderately well drained soils on flood plains. These soils formed in clayey alluvium.

In a representative profile the surface layer is dark-gray silty clay loam about 14 inches thick. The subsoil is about 27 inches thick. The upper part is very dark gray, firm heavy silty clay loam. The lower part of the subsoil is dark-gray, very firm silty clay that has common, dark-brown mottles. The underlying material is dark-gray silty clay that has dark-brown mottles.

Brewer soils have high available water capacity and slow permeability.

Representative profile of Brewer silty clay loam, in native grass meadow, about 1,330 feet north and 200 feet west of center of sec. 4, T. 29 S., R. 4 E.:

A1—0 to 14 inches, dark-gray (10YR 4/1) silty clay loam, black (10YR 2/1) when moist; moderate, medium, granular structure; hard when dry, friable when moist; many open pores; many roots; slightly acid; gradual, smooth boundary.

B1—14 to 21 inches, very dark gray (10YR 3/1) heavy silty clay loam, black (10YR 2/1) when moist; moderate,

fine, subangular blocky structure; extremely hard when dry, firm when moist; few open pores; thin patchy clay films; common roots; slightly acid; gradual, smooth boundary.

B2t—21 to 41 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) when moist; common, medium, distinct, dark-brown (7.5YR 4/4) mottles; moderate, medium, blocky structure; extremely hard when dry, very firm when moist; clay films cover all peds; few weak slickensides; few roots; few open pores; neutral; gradual, smooth boundary.

C—41 to 66 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) when moist; common, medium, distinct, dark-brown (7.5YR 4/4) mottles; massive; extremely hard when dry, very firm when moist; few open pores; neutral.

The A1 horizon is silt loam or silty clay loam and ranges from 8 to 18 inches in thickness. Its color ranges from dark gray to very dark grayish brown. Reaction is slightly acid to neutral. The B2t horizon is silty clay or clay 19 to 35 inches thick. Reaction is slightly acid to neutral, and the color range is the same as that for the A1 horizon.

Brewer soils are closely associated with Osage and Verdigris soils, especially on broader areas along flood plains. They have a coarser textured A1 horizon than Osage soils and are finer textured throughout than Verdigris soils.

Brewer silty clay loam (0 to 2 percent slopes) (Br).—This soil is in irregularly shaped areas on bottom lands of major streams. The areas range from 20 to 400 acres in size.

Included with this soil in mapping were small areas of Verdigris silt loam and Osage silty clay. These inclusions make up less than 20 percent of the acreage in the mapped areas. Verdigris soils are in narrow, irregular bands adjacent to the stream channels. Osage soils are in small concave areas.

Except for narrow, irregularly shaped areas adjacent to streams, most of this Brewer soil is cultivated. Runoff is slow. Flooding occurs, but serious damage to crops is infrequent. This soil is well suited to all the locally grown field crops, grasses, and trees. Management practices that maintain fertility and good tilth are needed. Capability unit I–2; Loamy Lowland range site; woodland suitability group 1; windbreak suitability group A.

Clime Series

This series consists of moderately deep, sloping and strongly sloping, moderately well drained or well drained soils on uplands. These soils formed in material weathered from calcareous shale.

In a representative profile the surface layer is very dark gray silty clay about 9 inches thick. The next layer is about 17 inches of light olive-brown, very firm silty clay. It is underlain by pale-olive, very firm silty clay. Calcareous clayey shale is at a depth of 33 inches.

Clime soils have low to moderate available water capacity and moderately slow permeability.

Representative profile of Clime silty clay from an area of Clime-Sogn complex, 3 to 15 percent slopes, in native rangeland, about 2,590 feet west and 700 feet north of southeast corner of sec. 9, T. 26 S., R. 8 E.:

A1—0 to 9 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) when moist; strong, fine and medium, granular structure; hard when dry, firm when moist; many fine roots; mildly alkaline; clear, smooth boundary.

AC—9 to 26 inches, light olive-brown (2.5Y 5/3) silty clay, olive brown (2.5Y 4/3) when moist; moderate, fine, subangular blocky structure; very hard when dry, very firm when moist; few fine roots; few fine lime concretions; strongly calcareous; moderately alkaline; clear, smooth boundary.

C—26 to 33 inches, pale-olive (5Y 6/3) silty clay, olive (5Y 5/3) when moist; few streaks, mostly adjacent to root channels, of very dark grayish brown (10YR 3/2); massive; extremely hard when dry, very firm when moist; few open pores; few fine roots; many fine and medium lime concretions; strongly calcareous; moderately alkaline; gradual, smooth boundary.

R—33 inches, about equal parts of light olive-gray (5Y 6/2) and pale-yellow (5Y 7/4), consolidated clayey shale, olive gray (5Y 5/2) and pale olive (5Y 6/4) when moist; moderate, medium, platy structure; extremely hard when dry, very firm when moist; few open pores; few nests of soft lime; few roots along cleavage planes; strongly calcareous; moderately alkaline.

The A1 horizon is heavy silty clay loam or silty clay and is 5 to 10 inches thick. It ranges from very dark gray to grayish brown. Reaction is mildly alkaline to moderately alkaline. The AC horizon is silty clay or light clay 10 to 20 inches thick. Its color ranges from light olive brown to brown. Reaction is mildly alkaline to moderately alkaline. The C horizon is pale-olive to pale-yellow silty clay or clay and is 5 to 10 inches thick. Depth to the R horizon ranges from 20 to 40 inches. Depth to free carbonates is less than 10 inches.

Clime soils are closely associated with Sogn soils, but they are deeper and more clayey than Sogn soils. They have a profile similar to that of Rosehill soils. Unlike Rosehill soils, however, which are free of calcareous material to a depth of 24 inches, Clime soils are calcareous within 10 inches of the surface.

Clime-Sogn complex, 3 to 15 percent slopes (Cs).—The soils in this complex are in irregular shaped areas that range from about 40 to 320 acres in size. This complex consists of about 45 percent Clime soils, 30 percent Sogn soils, and about 22 percent soils that have a profile similar to that of Sogn soils, except that calcareous shale is at a depth of 10 to 20 inches. The remaining 3 percent is shale and limestone outcrops. Clime soils have stronger slopes and occur at lower elevations than Sogn soils. Sogn soils are on narrow ridgetops and on the upper side slopes. Both Clime and Sogn soils have profiles described as representative of their series.

Erosion is a hazard where the grass cover is thin, or where cattle trails have developed into gullies. Runoff is medium to rapid, depending on the steepness of the slope.

These soils are used only for range. Capability unit VIe–3; Clime soils are in Limy Upland range site and in windbreak suitability group D; Sogn soils are in Shallow Limy range site and in windbreak suitability group G; not placed in a woodland suitability group.

Dwight Series

This series consists of moderately deep, nearly level and gently sloping, moderately well drained soils on uplands. These soils formed in clayey material over limestone and shale.

In a representative profile the surface layer is dark-gray silt loam about 5 inches thick. The subsoil is about 28 inches thick and is very firm, dark-brown silty clay. It is underlain by cherty limestone.

Dwight soils have low to moderate available water capacity and very slow permeability.

Representative profile of Dwight silt loam, 0 to 2 percent slopes, in native grass pasture, about 1,330 feet west and 70 feet south of northeast corner of sec. 2, T. 24 S., R. 7 E.:

A1—0 to 5 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; common roots; peds are slightly porous; slightly acid; abrupt, smooth boundary.

B21t—5 to 16 inches, dark-brown (7.5YR 3/2) silty clay, very dark brown (7.5YR 2/2) when moist; weak, medium, columnar structure; extremely hard when dry, very firm when moist; caps of columns coated with grayish silt; roots concentrated on faces of peds; few open pores; indistinct clay films; neutral; clear, smooth boundary.

B22t—16 to 26 inches, dark-brown (7.5YR 4/3) silty clay, dark brown (7.5YR 3/3) when moist; weak, medium, blocky structure; extremely hard when dry, very firm when moist; very few roots; thin patchy clay films; mildly alkaline; gradual, smooth boundary.

B3—26 to 33 inches, dark-brown (7.5YR 4/3) silty clay, dark brown (7.5YR 3/3) when moist; weak, medium, blocky structure; extremely hard when dry, very firm when moist; very few roots; thin patchy clay films; few iron-manganese and calcium carbonate concretions; moderately alkaline; abrupt, smooth boundary.

R—33 inches, cherty limestone that has a few vertical cracks filled with dark reddish-brown clay.

The A1 horizon is dark-gray to dark grayish-brown silt loam or silty clay loam, and ranges from 3 to 7 inches in thickness. Reaction is slightly acid to medium acid. The B horizon ranges from 20 to 35 inches in thickness, and is dark-brown to dark reddish-brown silty clay or clay. Reaction is neutral to moderately alkaline. In a few places the B3 horizon has mottles of gray, red, and brown. In most places the R horizon is limestone, cherty limestone, or shale. Depth to the R horizon ranges from 20 to 40 inches.

Dwight soils are closely associated with Labette soils. They are similar to Irwin and Ladysmith soils. They differ from these soils in having a thinner A1 horizon and a more abrupt texture change between the A1 and the B2t horizons.

In Butler County the depth of Dwight soils is a few inches less than the minimum in the defined range for the series. This soil is so nearly like Dwight soils in morphology, composition, and behavior, however, that a new series is not warranted.

Dwight silt loam, 0 to 2 percent slopes (Dt).—This soil is in irregularly shaped areas, most of which are about 80 acres in size. The largest areas are on broad upland divides where they are from 100 to nearly 400 acres in size. This soil has the profile described as representative of the Dwight series.

Included with this soil in mapping were a few small areas of Labette and Irwin soils. The Irwin soil is in areas where the soil mantle is more than 45 inches thick. The Labette soil is in the same landform as that of this soil. Small eroded areas of this soil are indicated on the map by symbols. Each symbol represents an area about 1 to 4 acres in size.

About 80 percent of this Dwight soil is used for range. If this soil is cultivated, controlling erosion and maintaining tilth and fertility are the main management needs. Runoff is medium.

Proper management that includes controlled grazing helps to maintain the cover of native grass on pastures. Capability unit IVs-1; Claypan range site; not placed in a woodland suitability group; windbreak suitability group E.

Dwight soils, 1 to 2 percent slopes, eroded (Dw).—These soils are mostly in small areas that range from 10 to 40 acres in size. They have a profile similar to the one described as representative of the Dwight series, except that much of the silt loam surface layer has been lost through erosion. In about 80 percent of the acreage, plowing has mixed material from the subsoil with that in the remaining surface layer. As a result the texture of the present plow layer is heavy silty clay loam or silty clay. The rest of the acreage is made up of small areas of Labette soils and of Dwight soils. Shallow gullies are in many of the areas.

This soil is in poor tilth. The surface layer crusts badly (fig. 4) and crops are difficult to establish. Because of the clayey surface layer and uncertain rainfall in summer, this soil is frequently too droughty for crops. Runoff is medium to rapid.

Nearly all of the acreage is abandoned cropland and is reverting to rangeland that has few desirable species of grass. Capability unit VIe-4; Claypan range site; not placed in a woodland suitability group; windbreak suitability group E.

Florence Series

This series consists of deep, sloping to strongly sloping, well-drained soils on uplands. These soils formed over cherty limestone.

In a representative profile (fig. 5), the surface layer is very dark gray cherty silt loam about 14 inches thick. The subsoil is about 31 inches thick. The upper part is very firm, dark reddish-brown cherty silty clay; and the lower part is very firm, dark reddish-brown, coarse cherty clay. The underlying material is cherty limestone that has a few cracks filled with red clay.

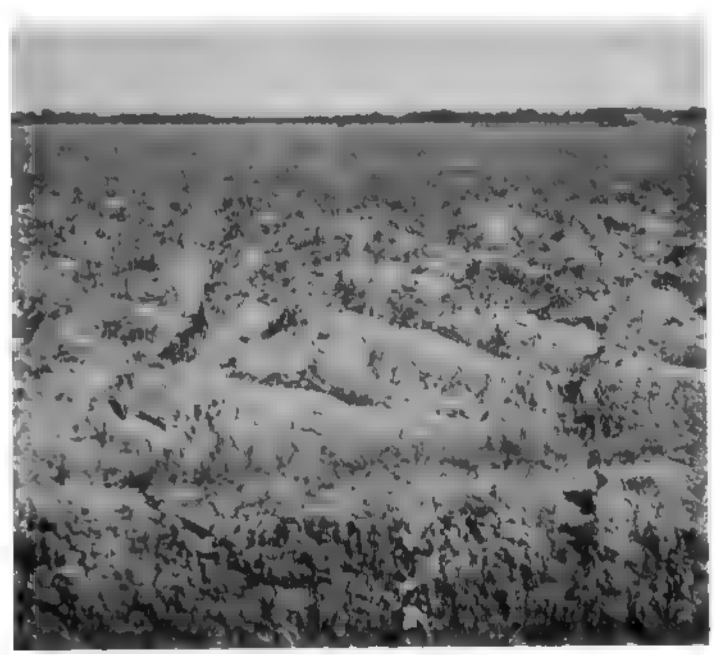

Figure 4.—Area of Dwight soils, 1 to 2 percent slopes, eroded, where the surface layer has crusted and cracked and many shallow gullies have formed.

Figure 5.—**Typical profile of a Florence cherty silt loam.**

Florence soils have low available water capacity and moderately slow permeability.

Representative profile of Florence cherty silt loam, 5 to 10 percent slopes, in range, about 2,600 feet north and 50 feet east of southwest corner sec. 8, T. 27 S., R. 8 E.:

A1 -0 to 14 inches, very dark gray (10YR 3/1) cherty silt loam, very dark brown (10YR 2/2) when moist; strong, medium, granular structure; slightly hard when dry, very friable when moist; many roots; upper 3 inches nearly chert free; about 75 percent of remainder of horizon consists of chert, 1 to 4 inches in diameter; slightly acid; gradual, wavy boundary.

B1—14 to 22 inches, dark reddish-brown (5YR 3/3) cherty silty clay, dark reddish brown (5YR 3/3) when moist; strong, fine, subangular blocky structure; extremely hard when dry, very firm when moist; common roots; thin continuous clay films; few open pores; 85 percent of soil mass is chert fragments, about 4 inches in diameter; slightly acid; gradual, wavy boundary.

B21t—22 to 35 inches, dark reddish-brown (2.5YR 3/4) coarse cherty clay, dark reddish brown (2.5YR 2/4) when moist; moderate, medium, blocky structure; extremely hard when dry, very firm when moist; few roots; continuous clay films; 85 percent of soil mass is coarse angular fragments of chert; few iron-manganese concretions; slightly acid; gradual, irregular boundary.

B22t—35 to 45 inches, dark reddish-brown (2.5YR 3/4) coarse cherty clay, dark reddish brown (2.5YR 3/4) when moist; moderate, medium, blocky structure; extremely hard when dry, very firm when moist; 85 percent of soil mass is coarse angular fragments of chert; thin patchy clay films; few lime concretions; few iron-manganese concretions; mildly alkaline; clear, irregular boundary.

R—45 inches, hard cherty limestone that has few vertical fractures filled with red clay.

The A1 horizon is cherty silt loam or cherty silty clay loam 10 to 16 inches thick. Its color ranges from very dark gray to very dark grayish brown. In places the uppermost 5 inches is nearly free of chert. Reaction in this horizon ranges from slightly acid to neutral. The B horizon ranges from 30 to 40 inches in thickness and is coarse, cherty clay or coarse, cherty silty clay. Reaction is slightly acid to mildly alkaline. In a few places the lower part of the B22t horizon is mottled. In most places the R horizon is cherty limestone, but in some areas it is limestone or shale. Depth to cherty limestone or shale is 40 to 60 inches.

Florence soils are associated with Benfield, Labette, and Sogn soils; and they have a profile similar to that of the Olpe, Labette, and Benfield soils. Unlike Olpe soils, which have rounded chert pebbles in the lower part of the B2t horizon and are stratified in that horizon, Florence soils have angular chert fragments in their B2t horizon. They have more chert in their B2t horizon than Labette soils and are deeper over limestone or shale. They are deeper than Sogn soils, which lack a B2t horizon. Florence soils are redder, more cherty in the B2t horizon, and deeper than Benfield soils.

Florence cherty silt loam, 5 to 10 percent slopes (Fc).—Most areas of this soil are narrow, but they are continuous and in places are more than a mile long. Most of them are between 40 and 200 acres in size and are irregular in shape.

Included with this soil in mapping were a few small areas of Dwight silt loam, Tully silty clay loam, and Labette cherty silty clay loam. Also included and making up about 15 percent of the acreage mapped were soils that are similar to this soil, except that the subsurface layer is light brown, and depth to the cherty clay subsoil is about 35 inches. These lighter colored soils are on the narrow, nearly level ridgetops.

This soil is used for range. Erosion is a hazard where the grass cover is thin or where cattle trails have developed into gullies. Runoff is medium. Capability unit VIe-2; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group F.

Goessel Series

This series consists of deep, nearly level and gently sloping, moderately well drained soils on uplands. These soils formed in clayey sediment.

In a representative profile (fig. 6), the surface layer is very dark gray silty clay about 18 inches thick. The next layer is about 26 inches thick. It is very firm, light

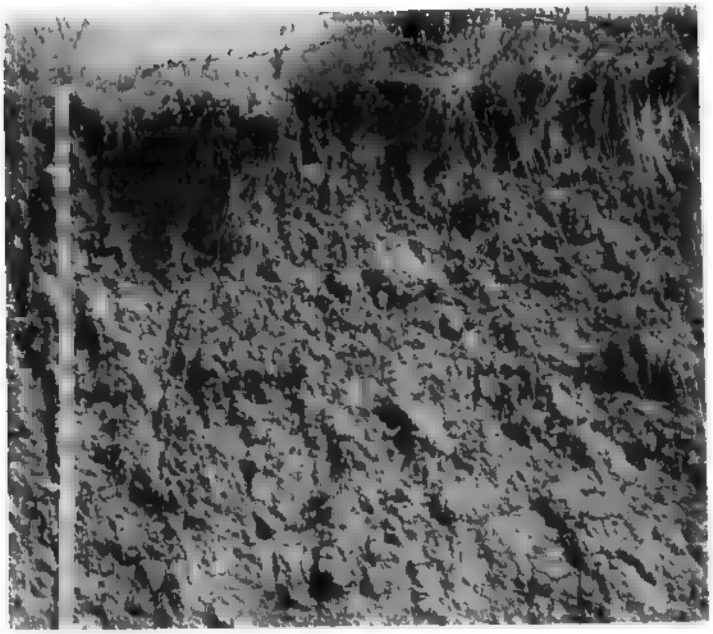

Figure 6.—Typical profile of a Goessel silty clay. Texture is nearly uniform throughout the profile.

Figure 7.—Fence constructed on a Goessel silty clay. The coiled spring takes up slack and provides tension.

olive-brown silty clay that has common slickensides. The underlying material is grayish-brown and light brownish-gray silty clay.

Goessel soils have high available water capacity and very slow permeability. Figure 7 shows the method of fence construction on these soils. The coiled spring takes up slack and provides tension as the soil shifts and churns.

Representative profile of Goessel silty clay, 0 to 1 percent slopes, in a cultivated field, about 2,340 feet north and 75 feet west of southeast corner sec. 18, T. 24 S., R. 3 E.:

Ap—0 to 7 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) when moist; moderate, fine and very fine, granular structure; surface crust, 1 millimeter thick; very hard when dry, firm when moist, very plastic and sticky when wet; slightly acid; clear, smooth boundary.

A1—7 to 18 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) when moist; moderate, fine, blocky structure with a subangular blocky component; extremely hard when dry, very firm when moist, sticky when wet; few open pores; few sand grains; slightly acid; gradual, smooth boundary.

AC—18 to 44 inches, light olive-brown (2.5Y 5/4) silty clay, olive brown (2.5Y 4/4) when moist; many streaks and splotches of very dark gray (10YR 3/1) and black (10YR 2/1) when moist; weak, fine and medium, blocky structure; extremely hard when dry, very firm when moist, plastic when wet; common, medium, strong slickensides inclined at a 45 degree angle from the horizontal; few sand grains; few soft masses of lime; few very fine iron-manganese concretions; neutral; gradual, smooth boundary.

C1—44 to 52 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (10YR 42) when moist; few, fine, faint mottles of yellowish brown, dark yellowish brown (10YR 4/6) when moist; massive; extremely hard when dry, very firm when moist, plastic when wet; few small lime concretions; many fine sand grains; few open pores; few fine iron-manganese concretions; few dark vertical streaks; mildly alkaline; gradual, smooth boundary.

C2—52 to 68 inches, light brownish-gray (10YR 6/2) silty clay, grayish brown (10YR 5/2) when moist; common, medium, faint mottles of yellowish brown, dark yellowish brown (10YR 4/6) when moist; massive; extremely hard when dry, very firm when moist, plastic when wet; few dark stains; few soft lime concretions; few sand grains; few fine iron-manganese concretions; moderately alkaline.

The Ap and A1 horizons are dark-gray or very dark gray heavy silty clay loam or silty clay, and their combined thickness is 10 to 20 inches. Reaction is slightly acid to neutral. The AC horizon is light olive-brown to dark-gray silty clay or clay 20 to 30 inches thick. Reaction is neutral to moderately alkaline. In some places the lower part of the AC horizon is mottled with strong brown. The C horizon is silty clay or clay; and, in a few places, it is somewhat stratified with clay loam and silty clay loam. These materials range from grayish brown to light brownish gray. Reaction is neutral to moderately alkaline. Mottles in this horizon range from few to common in abundance and from strong brown to yellowish brown in color.

Goessel soils are associated with Rosehill and Ladysmith soils, and their profile is similar to that of those soils. Goessel soils also have a profile similar to that of Osage soils, but they are better drained. They are deeper than Rosehill soils, which are underlain by shale at a depth of 20 to 40 inches. They have a finer textured Ap horizon than Ladysmith soils.

Goessel silty clay, 0 to 1 percent slopes (Go).—This soil occurs on broad plains. Most of the areas are irregularly shaped and range from 20 to 400 acres in size. This Goessel soil has the profile described as representative of the series.

Included with this soil in mapping were areas of Rosehill and Ladysmith soils. Rosehill soils make up about 15 percent of areas mapped and Ladysmith, 5 percent. Rosehill soils are in areas where the clayey sediment is less than 40 inches thick over shale beds. Ladysmith soils are in small areas.

Poor tilth, surface crusting and cracking, seasonal wetness, and slow runoff are limitations to use of this Goessel soil for crops. Nevertheless, most of this soil is used for crops. Soil blowing is a slight hazard if fields are allowed to remain bare in winter. Capability unit IIs-1; Clay Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Goessel silty clay, 1 to 3 percent slopes (Gs).—This soil has a profile similar to that described as represen-

tative of the series, but the surface layer is about 4 inches thinner. Most areas are irregularly shaped and range from about 20 to 80 acres in size.

Included with this soil in mapping are small areas of Rosehill and Irwin soils. Rosehill soils are in areas where the clayey sediment is less than 40 inches thick over shale beds. Irwin soils are in small, narrow areas near the periphery of the mapped areas.

Most of this Goessel soil is used for crops. Poor tilth, surface crusting and cracking, susceptibility to erosion, and medium runoff are limitations to use of this soil. Soil blowing is a hazard if fields are allowed to remain bare in winter. Capability unit IIIe–1; Clay Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Irwin Series

This series consists of deep, nearly level to sloping, moderately well drained or well drained soils on uplands. These soils formed in clayey sediment.

In a representative profile the surface layer is dark grayish-brown silty clay loam about 11 inches thick. The subsoil is about 31 inches thick. The upper part is dark grayish-brown, firm silty clay, and the lower part is brown, firm silty clay. The underlying material is reddish-brown silty clay.

Irwin soils have high available water capacity and very slow permeability.

Representative profile of Irwin silty clay loam, 1 to 3 percent slopes, in range, about 2,590 feet south and 200 feet east of northwest corner sec. 6, T. 25 S., R. 5 E.:

A1—0 to 11 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark gray (10YR 3/1) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist; roots common; many open pores; peds in lower 2 inches have gray coatings; slightly acid; clear, smooth boundary.

B21t—11 to 21 inches, dark-grayish brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; weak, medium, blocky structure; very hard when dry, firm when moist; continuous clay films; very few roots; few open pores; neutral; gradual, smooth boundary.

B22t—21 to 26 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; weak, medium, blocky structure; very hard when dry, firm when moist; continuous clay films; few roots; few open pores; neutral; gradual, smooth boundary.

B3—26 to 42 inches, brown (7.5YR 5/4) silty clay, dark brown (7.5YR 4/4) when moist; few, fine, faint mottles of yellowish red (5YR 4/8) when moist; weak, medium, blocky structure; very hard when dry, very firm when moist; few roots; few patchy clay films; few open pores; few fine iron-manganese concretions; few fine chert fragments; mildly alkaline; gradual, smooth boundary.

C1—42 to 46 inches, reddish-brown (5YR 4/4) silty clay, dark reddish brown (5YR 3/4) when moist; few, fine, distinct mottles of brownish yellow (10YR 6/6) when moist; massive; very hard when dry, firm when moist; moderately alkaline; gradual, smooth boundary.

C2—46 to 66 inches, reddish-brown (5YR 4/4) silty clay, dark reddish brown (5YR 3/4) when moist; many, medium, faint mottles of yellowish red (5YR 4/8) when moist, and few, medium, distinct mottles of light brownish gray (10YR 6/2) when moist; massive; very hard when dry, firm when moist; few open pores; few very small flakes of angular chert; few iron-manganese concretions; mildly alkaline.

The A1 horizon is dark-gray to very dark grayish-brown silty clay loam or silt loam 6 to 14 inches thick. Reaction is neutral to medium acid. The B horizon is brown to very dark grayish-brown silty clay or clay that is 25 to 48 inches thick. Reaction is neutral to moderately alkaline. The C horizon is silty clay or clay, which in some places grades to clayey shale at a depth of more than 40 inches.

Irwin soils are associated with Ladysmith, Dwight, Tully, and Labette soils, and their profile is similar to that of those soils. They have a thicker A1 horizon than Dwight soils, and the change in texture between the A1 and B2t horizons is less abrupt. Irwin soils are not so dark in the B21t horizon as Ladysmith soils. Irwin soils are less red in the B2t horizon than Labette soils, and they are deeper and do not have a B1 horizon. Irwin soils do not have the B1 horizon characteristic of Tully soils.

In mapping unit If, the A1 horizon is a few inches thinner than the minimum of the defined range for the series.

Irwin silty clay loam, 0 to 1 percent slopes (Ic).—Most areas of this soil are irregularly shaped and range from 80 to 200 acres in size. This soil has a profile similar to that described as representative of the series, but the surface layer is about 2 inches thinner.

Included with this soil in mapping were small areas of Ladysmith and Norge soils. The Ladysmith soil is in small nearly level areas. The Norge soil is near the periphery of some delineated areas.

Most of this Irwin soil is used for crops. Because of its clayey subsoil and uncertain rainfall in July and August, this soil is often too droughty for summer crops. Runoff is slow; and during seasons of heavy rainfall, this soil remains wet for long periods, and crops are damaged.

If this soil is cultivated, the chief management concerns are maintaining good tilth and an adequate level of fertility and alleviating the very slow movement of water in the subsoil. Soil blowing is a hazard if cultivated areas are left bare in winter. Capability unit IIs–1; Clay Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Irwin silty clay loam, 1 to 3 percent slopes (Id).—This soil is in irregularly shaped areas that range from 20 to 500 acres in size. It has the profile described as representative of the series. In unplowed areas the surface layer is about 11 inches thick, but in most cultivated areas it is about 9 inches thick.

Included with this soil in mapping were some small areas of Ladysmith, Dwight, and Labette soils. The Ladysmith soil is in small nearly level areas. The Labette and Dwight soils are in areas where the thickness of the clayey sediment is 40 inches or less over bedrock. A few eroded areas of Irwin soil, less than 4 acres and more than 1 acre in size, were also included. These areas are identified by symbols on the soil map.

About half of this Irwin soil is used for crops and about half for range. Runoff is medium in cultivated areas.

The main management concerns in cultivated areas are controlling erosion, maintaining good tilth and an adequate level of fertility, and improving the percolation rate in the subsoil. Capability unit IIIe–1; Clay Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Irwin silty clay loam, 3 to 5 percent slopes (Ie).—This soil occurs as narrow bands that are generally adjacent

to small intermittent drainageways and in association with Irwin silty clay loam, 1 to 3 percent slopes. Most of the areas are less than 60 acres in size. The profile of this soil is similar to the one described as representative of the Irwin series, but in some places small chert fragments are on the surface.

Included with this soil in mapping were small areas of Tully, Norge, and Labette soils that are in small pockets adjacent to drainageways. Small eroded areas of Irwin soil that are less than 4 acres but more than 1 acre in size were also included. These areas are shown by symbols on the soil map.

Most of this Irwin soil is used as range, and it is well suited to this use. If this soil is cultivated, the main concerns of management are controlling water erosion, maintaining fertility and tilth, reducing runoff, and improving the movement of water in the subsoil. Capability unit IIIe-7; Clay Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Irwin silty clay loam, 2 to 5 percent slopes, eroded (If).—This soil is in areas that are mostly irregular in shape and less than 40 acres in size. It has a profile that is similar to that described for the series, but the surface layer has been thinned by erosion. Rills and shallow gullies are in many areas. The surface layer is about 5 inches thick and is mostly heavy silty clay loam.

Included with this soil in mapping were small areas of Dwight silt loam.

Most of this Irwin soil is used for crops. Some areas are reverting to rangeland, and some are being seeded to grass. The main concerns in management are improving tilth and fertility, controlling erosion, preventing surface crusting, and reducing the rate of runoff. If well managed, this soil can be used for crops, but with severe limitations. Capability unit IVe-1; Claypan range site; not placed in a woodland suitability group; windbreak suitability group E.

Labette Series

This series consists of moderately deep, gently sloping and sloping, well-drained soils on uplands. These soils formed in material weathered from limestone and shale.

In a representative profile the surface layer is dark grayish-brown light silty clay loam about 13 inches thick. The subsoil is about 25 inches thick. The upper part is firm, dark-brown light silty clay. The middle part is firm, yellowish-red silty clay, and the lower part is firm, yellowish-red heavy silty clay loam. It is underlain by cherty limestone.

Labette soils have low to moderate available water capacity and slow permeability.

Representative profile of Labette silty clay loam, 1 to 3 percent slopes, in range, about 2,590 feet south and 1,300 feet east of northwest corner of sec. 8, T. 29 S., R. 7 E.:

A1—0 to 13 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; strong, medium, granular structure; hard when dry, very friable when moist; few open pores; many roots; slightly acid; gradual, smooth boundary.

B1—13 to 18 inches, dark-brown (7.5YR 3/2) light silty clay, dark reddish brown (5YR 3/4) when moist; strong, fine and very fine, subangular blocky structure; very hard when dry, firm when moist; few open pores; slightly acid; gradual, smooth boundary.

B2t—18 to 31 inches, yellowish-red (5YR 4/6) light silty clay, dark reddish brown (5YR 3/4) when moist; moderate, fine, subangular blocky structure; very hard when dry, firm when moist; few open pores; few, thin, patchy clay films; slightly acid; gradual, smooth boundary.

B3—31 to 38 inches, yellowish-red (5YR 4/6) heavy silty clay loam, yellowish red (5YR 3/6) when moist; moderate, fine, blocky structure; very hard when dry, firm when moist; thin patchy clay films; few, fine, angular chert fragments; few iron-manganese concretions; slightly acid; abrupt boundary.

R—38 inches, cherty limestone.

The A1 horizon is silty clay loam or silt loam 8 to 14 inches thick. It ranges from very dark gray to dark brown or dark grayish brown. Reaction is slightly acid to medium acid. The B1 horizon is silty clay loam or light silty clay 4 to 6 inches thick, and it ranges from dark brown to dark reddish brown. Reaction is slightly acid to medium acid. The B2t and B3 horizons are dark-brown to yellowish-red silty clay or heavy silty clay loam and are 10 to 20 inches thick. Reaction is slightly acid to moderately alkaline in these horizons. The R horizon is limestone, cherty limestone, or shale. In places less than 5 percent of the material in these soils is chert fragments. Depth to limestone or shale is 20 to 40 inches.

Labette soils are associated with Irwin, Dwight, Florence, Benfield, and Sogn soils. They are redder and shallower than Irwin soils, and they change more gradually between the A1 and B2t horizons. They have less chert in the B2t horizon than Florence soils and they are shallower than those soils. Labette soils are deeper than the shallow Sogn soils, which lack a B2t horizon. They have a thicker A1 horizon than Dwight soils, and they lack the abrupt texture change between the A1 and the B2t horizons that is characteristic of Dwight soils. Labette soils have a redder B2t horizon than Benfield soils.

In mapping unit Lb, the surface layer is thinner than the minimum in the defined range for the series.

Labette silty clay loam, 1 to 3 percent slopes (La).—This soil is in irregularly shaped areas that are between 40 and 100 acres in size. It has the profile described as representative of the series.

Included with this soil in mapping were very small areas of Dwight silt loam and small areas of Irwin silty clay loam. The Dwight soil occurs throughout the mapped areas, and the Irwin soil is near the boundaries of these areas where the clayey sediment is thicker. The Dwight and Irwin soils make up less than 15 percent of the mapped areas. Also included in mapping were a few areas of Labette silty clay loam, 1 to 3 percent slopes, eroded, that are larger than 1 acre and less than 4 acres in size. These eroded areas are shown on the soil map by symbols.

Most of this Labette soil is used for range. If this soil is cultivated, control of water erosion and maintenance of tilth and fertility are needed. Runoff is medium on this soil. Capability unit IIe-3; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Labette silty clay loam, 1 to 3 percent slopes, eroded (Lb).—Most of the areas of this soil are less than 20 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer has been thinned to about 5 inches by erosion, and the plow layer is more clayey. The surface layer is dark-brown heavy silty clay loam in about 80 percent of the mapped areas.

Included with this soil in mapping were small areas of Dwight silt loam and Irwin silty clay loam.

Most of this Labette soil is used for field crops. Some areas formerly cultivated are idle, and other areas have been reseeded to grass. This soil is in poor tilth, and erosion has removed plant nutrients. The surface layer crusts, and plants are difficult to establish in places. The soil is somewhat droughty, and most areas contain gullies.

If this soil is used for field crops, the main management concerns are controlling surface crusting, runoff, and erosion and maintaining good tilth and fertility. Capability unit IIIe-3; Clay Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Labette silty clay loam, 3 to 5 percent slopes (Lc).—This soil is in narrow areas that generally are adjacent to small intermittent drainageways. Most areas are less than 40 acres in size. This soil has a profile similar to that described as representative of the series; but in places the underlying material is shale rather than limestone, and in some areas chert fragments are on the surface.

Included with this soil in mapping were small areas of Tully silty clay loam and Irwin silty clay loam. These soils make up less than 10 percent of the mapped areas. Small eroded areas are shown on the soil map by symbols. Each symbol represents an area about 1 to 4 acres in size.

Nearly all of this Labette soil is used for range. If this soil is cropped, runoff is rapid and water erosion is a serious hazard. Capability unit IIIe-8; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Labette-Dwight complex, 1 to 3 percent slopes (Ld).—The areas of the soils in this complex are irregularly shaped. These soils are on rather broad upland divides. Most areas are more than 100 acres in size. The complex consists of about 50 percent Labette soils, 40 percent Dwight soils, and 10 percent Irwin silty clay loam and Ladysmith soils. Small eroded areas are shown on the soil map by symbols. Each symbol represents an area about 1 to 4 acres in size. The soils in this complex have profiles similar to those described as representative of their respective series.

Most areas of these soils are used for range, but some small areas are cultivated. The main management concerns in cultivated areas are controlling water erosion and maintaining good tilth and fertility. Runoff is medium. Capability unit IIIe-2; Labette soils are in Loamy Upland range site and windbreak suitability group C; Dwight soils are in Claypan range site and windbreak suitability group E; not placed in a woodland suitability group.

Labette-Sogn complex, 2 to 8 percent slopes (Le).—The soils in this complex are in irregularly shaped areas that range from 40 to 200 acres in size. The complex consists of about 50 percent Labette silty clay loam, 45 percent Sogn soils, and about 5 percent limestone and shale outcrop. Each soil has a profile similar to that described as representative of its respective series.

Sinkholes are common in this complex (fig. 8) and are shown on the soil map by symbols. Runoff is medium to rapid.

All of the acreage in this complex is used for range. Shallow soil and rock outcrop make common tillage operations impractical. Capability unit VIe-1; Labette soils are in Loamy Upland range site and windbreak suitability group C; Sogn soils are in Shallow Limy range site and windbreak suitability group G; not placed in a woodland suitability group.

Figure 8.—**Area of Labette-Sogn complex, 2 to 8 percent slopes. A sinkhole is in the foreground.**

Ladysmith Series

This series consists of deep, nearly level and gently sloping, moderately well drained and somewhat poorly drained soils on uplands. These soils formed in clayey sediment.

In a representative profile the surface layer is dark-gray light silty clay loam about 8 inches thick. The subsoil is about 30 inches thick. The upper part is very firm, very dark grayish-brown silty clay, and the lower part is very firm, dark grayish-brown silty clay. The underlying material is mixed yellowish-red and grayish-brown light silty clay in the upper part and dark-red and brown clay in the lower part.

Ladysmith soils have high available water capacity and very slow permeability.

Representative profile of Ladysmith silty clay loam, 0 to 2 percent slopes, in range, about 5,140 feet west and 100 feet south of the northeast corner sec. 30, T. 25 S., R. 8 E.:

A1—0 to 8 inches, dark-gray (10YR 4/1) light silty clay loam, black (10YR 2/1) when moist; weak, fine and medium, granular structure; slightly hard when dry, friable when moist; many fine roots; common open pores; slightly acid; clear, smooth boundary.

B21t—8 to 18 inches, very dark grayish-brown (10YR 3/2) silty clay, very dark brown (10YR 2/2) when moist; few, fine, distinct mottles of strong brown (7.5YR 4/8) when moist; weak, medium, blocky structure that parts to weak, fine, blocky; very hard when dry, very firm when moist; roots concentrated on faces of peds; few open pores; thin continuous clay films; slightly acid; gradual, smooth boundary.

B22t—18 to 34 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; few, fine, distinct mottles of strong brown (7.5YR 4/8) when moist; weak, medium, blocky structure; very hard when dry, very firm when moist; few open pores; very few roots; thin continuous clay films; slightly acid; gradual, smooth boundary.

B3—34 to 38 inches, about equal parts pale-brown (10YR 6/3), brown (10YR 5/3) when moist, and strong-brown (7.5YR 5/6), strong-brown (7.5YR 4/6) when moist, and streaks of very dark grayish-brown, light silty clay; weak, medium, blocky structure; very hard when dry, very firm when moist; few open pores; few fine roots; few very fine iron-manganese concretions; moderately alkaline; gradual, smooth boundary.

C1—38 to 55 inches, about two-thirds of mass is yellowish-red (5YR 4/6) light silty clay, yellowish red (5YR 3/6) when moist, and one-third is grayish-brown (10YR 5/2) light silty clay, dark grayish brown (10YR 4/2) when moist; massive; very hard when dry, very firm when moist; few open pores; few fine iron-manganese concretions; moderately alkaline; gradual, smooth boundary.

C2—55 to 66 inches, about two-thirds of mass is dark-red (2.5YR 3/6) when dry and when moist and one-third brown (10YR 5/3), dark-brown (10YR 4/3) when moist, clay; massive; extremely hard when dry, very firm when moist; few open pores; few fine iron manganese concretions; moderately alkaline.

The A1 horizon is gray to very dark gray silt loam or silty clay loam 6 to 14 inches thick. Reaction is neutral to medium acid. The combined thickness of the B21t and the B22t horizons ranges from 20 to 44 inches. Color in these horizons ranges from dark gray to very dark grayish brown. Reaction is slightly acid to moderately alkaline. The B3 horizon is dark grayish-brown to pale-brown silty clay or silty clay loam that is 2 to 8 inches thick. Reaction is mildly alkaline to moderately alkaline. The C horizon, in most places, is silty clay; but it ranges from clay to silty clay loam. This material has variegated colors of yellowish red, grayish brown, and dark red. Reaction ranges from mildly alkaline to moderately alkaline.

Ladysmith soils are associated with Irwin, Goessel, and Dwight soils. Their profile is similar to the profile of those soils. Ladysmith soils are darker in the B21t horizon than Irwin soils. They have a thicker A1 horizon than Dwight soils, and the change of texture between the A1 and B21t horizons is less abrupt. Ladysmith soils are less clayey in the A1 horizon than Goessel soils.

Ladysmith silty clay loam, 0 to 2 percent slopes (Ls).—This soil occurs on broad upland divides, on slightly convex landforms, and on high, nearly level terraces. Areas are irregular in shape and range from 20 to 160 acres in size.

Included with this soil in mapping and making up 10 percent of the mapped areas are some small areas of Irwin silty clay loam and Dwight silt loam.

About 60 percent of this Ladysmith soil is used for range, and the rest is used for field crops. If this soil is cultivated, maintaining tilth and fertility and improving movement of water in the subsoil and the slow runoff are concerns of management. On long slopes sheet erosion is a hazard. Capability unit IIs-1; Clay Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Norge Series

This series consists of deep, nearly level to sloping, well-drained soils on high terraces and uplands. These soils formed in loamy sediment.

In a representative profile the surface layer is dark-brown heavy silt loam about 9 inches thick. The subsoil is about 63 inches thick. The upper 9 inches is friable, reddish-brown silty clay loam. The next 24 inches is firm, reddish-brown silty clay loam; and the lower 30 inches is firm, yellowish-red silty clay loam.

Norge soils have high available water capacity and moderately slow permeability.

Representative profile of Norge silt loam, 1 to 3 percent slopes, in range, about 1,460 feet east and 2,520 feet north of southwest corner sec. 3, T. 29 S., R. 4 E.:

A1—0 to 9 inches, dark-brown (7.5YR 4/2) heavy silt loam, dark brown (7.5YR 3/2) when moist; moderate, fine and medium, granular structure; slightly hard when dry, very friable when moist; few open pores; roots common; slightly acid; gradual, smooth boundary.

B1—9 to 18 inches, reddish-brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/4) when moist; strong, fine, subangular blocky structure; hard when dry, friable when moist; few open pores; thin and patchy clay films; slightly acid; gradual, smooth boundary.

B21t—18 to 32 inches, reddish-brown (5YR 4/5) silty clay loam, dark reddish brown (5YR 4/5) when moist; strong, medium, blocky structure; very hard when dry, firm when moist; many open pores; thin and continuous clay films; few fine iron-manganese concretions; slightly acid; gradual, smooth boundary.

B22t—32 to 42 inches, reddish-brown (5YR 5/5) heavy silty clay loam, yellowish red (5YR 5/6) when moist; weak, medium, blocky structure; very hard when dry, firm when moist; thin and continuous clay films; few open pores; few fine iron-manganese concretions; slightly acid; gradual, smooth boundary.

B31—42 to 56 inches, yellowish-red (5YR 5/6) heavy silty clay loam, yellowish red (5YR 4/6) when moist; weak, medium, blocky structure; very hard when dry, firm when moist; few small iron-manganese concretions; few roots; slightly acid; gradual, smooth boundary.

B32—56 to 72 inches, yellowish-red (5YR 5/6) silty clay loam, yellowish red (5YR 4/6) when moist; weak, coarse, blocky structure; very hard when dry, friable when moist; few roots; slightly acid.

The A horizon ranges from brown to dark brown and is silt loam or light silty clay loam 7 to 12 inches thick. Reaction is slightly acid to medium acid. The B1 horizon ranges from dark brown to dark reddish brown and is heavy silt loam or silty clay loam 5 to 12 inches thick. Reaction is slightly acid to medium acid. The B21t and B22t horizons are silty clay loam or heavy silty clay loam 20 to 40 inches thick, and they range from reddish brown to yellowish red and dark reddish brown. Reaction is neutral to slightly acid in these horizons. In most places the B3 horizon is silty clay loam, but it ranges to heavy silt loam in places. Its color ranges from yellowish red to reddish brown. Reaction is neutral to slightly acid. In some places chert pebbles are in thin lenses.

Norge soils are closely associated with Olpe soils and have a profile similar to that of the Labette, Tully, and Vanoss soils. Norge soils are coarser textured than Olpe soils and they lack the chert pebbles in the Bt horizon that are characteristic of those soils. They are less clayey in the B2t horizon than Labette soils and are deeper over bedrock. Norge soils are redder and less clayey in the B2t horizon than Tully soils. They are redder in the B2t horizon than Vanoss soils.

In mapping unit Nt, the A horizon and the upper part of the B1 horizon are a few inches thinner than the minimum defined range for the series. These differences, however, do not greatly alter its behavior and usefulness.

Norge silt loam, 0 to 1 percent slopes (No).—This soil is in irregularly shaped areas that are mainly 40 to 80 acres in size. It has a profile that is similar to the one described as representative of the series, but the surface layer is 2 inches thicker, and it is slightly darker.

Included with this soil in mapping were a few small areas of Ladysmith silty clay loam and Vanoss silt loam. The Ladysmith soil is in nearly level areas. The Vanoss soil is slightly undulating in a few places.

Nearly all of this Norge soil is cultivated. This soil is well suited to all of the locally grown crops and grasses. If well managed, it can be cropped intensively. Runoff is slow. Capability unit I-1; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Norge silt loam, 1 to 3 percent slopes (Nr).—This soil is mostly on terraces in valleys, but a few areas are on uplands. Most areas are irregular in shape and less than 80 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping were a few small areas of Tully soils in the Vanoss and Irwin series. These areas are near the periphery of the mapped areas and make up less than 15 percent of the areas mapped. Small eroded areas are shown on the soil map by symbols. Each symbol represents an area about 1 to 4 acres in size.

This Norge soil is easy to farm, and most of it is cultivated. If this soil is well managed, it can be cropped intensively. It is easily worked and has no serious limitation to use for crops. Water erosion is a slight hazard. Runoff is medium. Capability unit IIe-1; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Norge silt loam, 3 to 5 percent slopes (Ns).—This soil is mainly between flood plains and uplands. Most areas are narrow and are less than 60 acres in size. This soil has a profile that is similar to the one described as representative of the Norge series, but the surface layer is about 2 inches thinner.

Included with this soil in mapping were a few small areas of soils in the Tully and Olpe series and a few areas where thin layers of gravel are at a depth below 20 inches. These inclusions make up less than 15 percent of the areas mapped. Small eroded areas are shown on the map by symbols. Each symbol represents an area about 1 to 4 acres in size.

Most of this Norge soil is cultivated. Runoff is medium. The main management needs if this soil is cultivated are controlling water erosion, maintaining satisfactory tilth and fertility, and reducing runoff. Capability unit IIIe-5; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Norge silty clay loam, 3 to 5 percent slopes, eroded (Nt).—This soil is commonly adjacent to Norge silt loam in narrow areas that are less than 30 acres in size. It has a profile that is similar to the one described as representative of the series, but the surface layer is reddish-brown silty clay loam about 5 inches thick. In addition, some light-colored slickspots are in the eroded areas. Rills are evident around the heads of drainageways and sheet erosion is common on the more uniform slopes. Gullied areas are shown on the soil map by a symbol for gully.

Included with this soil in mapping were a few small areas of Norge soils that make up less than 20 percent of the areas mapped.

Most of this Norge soil is cultivated, but a few areas are reverting to range. Maintaining good tilth and fertility and controlling water erosion and rapid runoff are the chief management needs associated with this soil. Capability unit IIIe-6; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Oil-Waste Land

Oil-waste land (2 to 12 percent slopes) (Od) consists of areas that have been severely affected by oil, salt water, or other wastes from oil wells, drilling operations, or similar oil-related activities. These areas are nearly void of vegetation, and in many areas the land is actively eroding. It is not possible to identify the original soil in most of the areas. Even though Oil-waste land is in all parts of the landscape, most of it is in or around drainageways in the oil-producing areas of the county. Most areas of this land are smaller than 20 acres in size. Those smaller than 4 acres are shown on the soil map by a symbol. This land is unsuitable for crops or for grazing. Capability unit VIIIs-1; not placed in a range site, a woodland suitability group, or a windbreak suitability group.

Olpe Series

This series consists of deep, gently sloping and sloping, well-drained soils on high terraces and uplands. These soils formed in gravelly clayey sediment.

In a representative profile (fig. 9), the surface layer is dark-brown silty clay loam about 10 inches thick. The subsoil is about 45 inches thick. The upper 4 inches is firm, dark reddish-gray heavy silty clay loam; the next 16 inches is very firm, dark-red gravelly clay; and the lower 25 inches is red clay and pale-brown gravelly clay.

Olpe soils have moderate available water capacity and slow and very slow permeability.

Representative profile of an Olpe silty clay loam in an area of Olpe-Norge complex, 2 to 7 percent slopes, in native range, about 800 feet south and 150 feet west of northeast corner of sec. 26, T. 26 S., R. 7 E.:

A1—0 to 10 inches, dark-brown (7.5YR 3/2) silty clay loam, very dark brown (7.5YR 2/2) when moist; strong, fine, granular structure; slightly hard when dry; friable when moist; few open pores; rounded chert pebbles about one-half inch in diameter make up 5 percent of this horizon; medium acid; gradual, smooth boundary.

B1—10 to 14 inches, dark reddish-gray (5YR 4/2) heavy silty clay loam, dark reddish brown (5YR 3/2) when moist; strong, fine and very fine, subangular blocky structure; hard when dry; firm when moist; thin and patchy clay films; about 10 percent of this horizon is chert pebbles one-half inch in diameter; slightly acid; gradual, smooth boundary.

B21—14 to 30 inches, dark-red (2.5YR 3/6) gravelly clay, has the same color when moist; moderate and strong, fine, blocky structure; extremely hard when dry, very firm when moist; continuous clay films that clog some pores and cover the surface of some pebbles; about 85 percent of this horizon is rounded chert pebbles; slightly acid; clear, wavy boundary.

B22t—30 to 42 inches, red (2.5YR 4/6) clay, dark red (2.5YR 3/6) when moist; moderate, medium, blocky structure; extremely hard when dry, very firm when moist; distinct, thick, and continuous clay films; these films impart a dark-brown (7.5YR 4/2) dry color to ped surfaces; about 10 percent of horizon is rounded

Figure 9.—Typical profile of an Olpe silty clay loam. A layer that is nearly free of gravel is at a depth of about 3 feet.

chert gravel; few, hard, black iron-manganese concretions; neutral; clear, wavy boundary.

B3—42 to 55 inches, pale-brown (10YR 6/3) gravelly clay, brown (10YR 5/3) when moist; many fine and medium mottles of black (10YR 2/1), grayish brown (2.5Y 5/2), and yellowish brown (10YR 5/6) and many, medium, prominent mottles of dark red (2.5YR 3/6); weak, fine, blocky structure; extremely hard when dry, very firm when moist; thick and patchy clay films; 80 percent of this horizon is rounded chert gravel; few, soft, black concretions; mildly alkaline.

The A1 horizon is silt loam, silty clay loam, or gravelly silty clay loam and is 7 to 15 inches thick. Its color ranges from dark gray to dark brown. Reaction is slightly acid to medium acid. The B1 horizon is heavy silty clay loam, gravelly silty clay loam, or gravelly silty clay and is 2 to 6 inches thick. Its color is dark reddish gray to dark reddish brown. Reaction is medium acid to neutral. The B21t and B22t horizons are gravelly clay or gravelly silty clay and are 20 to 45 inches thick. Color of the B2t horizon ranges from red to dark reddish brown. Reaction is neutral to medium acid. In most places the B3 horizon consists of stratified gravel and clay. Its color ranges from pale brown to dark red and commonly is highly mottled. Layers of clay that are nearly free of gravel are common in the Bt and B3 horizons, but the B horizon is more than 50 percent gravel.

Olpe soils have a profile that is similar to those of the soils in the Florence series. Olpe soils are closely associated with soils of the Norge series. Olpe soils have rounded chert pebbles and gravel in the B2t horizon, which become stratified in the lower part of the B2t horizon; but Florence soils have angular chert fragments in the B2t horizon and no stratification of the fragments. Soils in the Olpe series are more clayey and more gravelly in the B horizon than soils of the Norge series.

In mapping unit On, the Olpe soils are less moist than the minimum defined range for the series, but this difference does not alter the usefulness or behavior of the soil.

Olpe-Norge complex, 2 to 7 percent slopes (On).—The soils in this complex are undulating. The areas are irregular in shape and range from 20 to 200 acres in size. This complex consists of 50 percent Olpe soils, 30 percent Norge soils, and 20 percent Irwin soils. Olpe soils are on crests and Norge soils are between crests. The Olpe soil has a profile similar to the one described as representative of its series, except that in most places the surface layer is gravelly silty clay loam. The Norge soil has a profile similar to the one described as representative of its series, except that in some places a few pebbles are scattered throughout the profile.

These soils are used for range. Also, gravel for roads is removed from many areas. Runoff is medium to rapid. Some erosion has occurred where the cover of grass is thin, or where excavations have been made. Capability unit VIe–2; Loamy Upland range site; not placed in a woodland suitability group; Norge soils in windbreak suitability group C, and Olpe soils in windbreak suitability group F.

Osage Series

This series consists of deep, nearly level, poorly drained soils on bottom lands. These soils formed in clayey alluvial sediment.

In a representative profile the surface layer is very dark gray silty clay about 18 inches thick. The next layer is about 15 inches thick. It is firm, dark-gray, distinctly mottled silty clay. The underlying material is mottled gray silty clay.

Osage soils have high available water capacity and very slow permeability.

Representative profile of Osage silty clay, in a cultivated field, about 1,330 feet east and 1,330 feet south of the northwest corner of sec. 20, T. 25 S., R. 3 E.:

Ap—0 to 8 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) when moist; weak, fine, granular structure; very hard when dry, firm when moist; neutral; clear, smooth boundary.

A1—8 to 18 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) when moist; weak, fine, subangular blocky structure; very hard when dry, firm when moist; few open pores; few roots; neutral; gradual, smooth boundary.

ACg—18 to 33 inches, dark-gray (10YR 4/1) silty clay, black (10YR 2/1) when moist; few, fine, distinct mottles of strong brown (7.5YR 5/6); weak, fine, blocky structure; very hard when dry, firm when moist; few open pores; few roots; slightly acid; gradual, smooth boundary

Cg—33 to 66 inches, gray (10YR 5/1) silty clay, dark gray (10YR 4/1) when moist; many, medium, faint mottles of brown (10YR 5/3) and few, fine, distinct mottles of strong brown (7.5YR 5/6); massive; very hard when dry, firm when moist; few open pores; few, very small, black concretions; neutral.

The A horizon is silty clay or heavy silty clay loam and is 10 to 20 inches thick. It ranges from dark gray to very dark grayish brown. Reaction is slightly acid to mildly alkaline. The ACg horizon is silty clay or clay and is 10 to 20 inches thick. Its color range is the same as that of the A horizon. The Cg horizon is gray to very dark gray silty clay or clay. Reaction is neutral to moderately alkaline.

Osage soils are associated with Brewer and Verdigris soils. Their profile is similar to that of Goessel soils. Osage soils

are finer textured in the A horizon than Brewer soils. They are finer textured in all horizons than Verdigris soils, and they are more poorly drained than those soils. Osage soils are more poorly drained than Goessel soils.

Osage silty clay (0 to 1 percent slopes) (Os).—This soil is in irregularly shaped areas. The areas range from 20 to 140 acres in size.

Included with this soil in mapping were a few small areas of Brewer silty clay loam near the periphery of the mapped areas.

Most of this Osage soil is used for crops. Poor tilth, surface crusting and cracking, poor drainage, and slow runoff are limitations to use of this soil. Water is often ponded in wet periods. There is a slight soil blowing hazard if fields are allowed to remain bare in winter. Capability unit IIIw–1; Clay Lowland range site; woodland suitability group 2; windbreak suitability group B.

Rosehill Series

This series consists of moderately deep, gently sloping, well-drained soils on uplands. These soils formed in material weathered from clayey shale.

In a representative profile the surface layer is dark-gray silty clay about 9 inches thick. The next layer is about 18 inches thick. It is firm, dark grayish-brown silty clay in the upper part and firm, dark grayish-brown and olive silty clay in the lower part. The underlying material is grayish-brown shaly clay. Shale is at a depth of 36 inches.

Rosehill soils have moderate available water capacity and very slow permeability.

Representative profile of Rosehill silty clay, 1 to 3 percent slopes, in a cultivated field, about 1,220 feet south and 250 feet east of northwest corner of sec. 17, T. 26 S., R. 3 E.:

Ap—0 to 9 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) when moist; weak, medium, granular structure; very hard when dry, firm when moist; few open pores; few shale fragments; neutral; clear, smooth boundary.

AC1—9 to 19 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; weak, fine, blocky structure; very hard when dry, firm when moist; few open pores; neutral; gradual, smooth boundary.

AC2—19 to 27 inches, mixed colors of dark grayish-brown (2.5Y 4/2) and olive (5Y 5/4) silty clay, very dark grayish brown (2.5Y 3/2) and olive (5Y 4/4) when moist; fine, blocky structure; very hard when dry, firm when moist; few shale fragments; few open pores; moderately alkaline, noncalcareous; gradual, smooth boundary

C—27 to 36 inches, grayish-brown (2 5Y 5/2) shaly clay, dark grayish brown (2.5Y 4/2) when moist; few shale fragments of reddish brown (5YR 5/3); weak, fine, blocky structure; very hard when dry, firm when moist; few dark organic stains adjacent to root channels; few open pores; few small lime concretions; soil mass is moderately alkaline, noncalcareous; gradual, smooth boundary.

R—36 inches, about equal parts light olive-gray (5Y 6/2) and reddish-brown (5YR 5/3) clayey shale; moderately alkaline, noncalcareous; segregated lime in the shale partings.

The Ap horizon is silty clay or heavy silty clay loam about 8 to 13 inches thick. Its color ranges from dark gray to very dark grayish brown. Reaction is neutral to slightly acid. The AC horizons are silty clay or clay and are 12 to 27 inches thick. Their colors range from dark grayish brown to pale yellow. Reaction ranges from neutral to moderately alkaline. The C horizon is clay or silty clay. Its color ranges from dark grayish brown to pale yellow. Reaction is mildly alkaline or moderately alkaline. Depth to the R horizon ranges from 20 to 40 inches. In most places the clayey shale that underlies the soil is noncalcareous, but in some places the shale is calcareous. This shale material ranges from olive gray to reddish brown.

Rosehill soils have a profile similar to that of the Clime and Goessel soils, and they are closely associated with Goessel soils. Rosehill soils are not calcareous within 24 inches of the surface, whereas Clime soils are calcareous within 10 inches of the surface. Rosehill soils are thinner than Goessel soils.

Rosehill silty clay, 1 to 3 percent slopes (Ro).—This soil is in irregularly shaped areas. The areas range from about 20 to 160 acres in size.

Included with this soil in mapping were a few small areas of Goessel, Clime, and Irwin soils. These inclusions make up less than 15 percent of the areas mapped. Small eroded areas are shown on the soil map by symbols. Each symbol represents an area about 1 to 4 acres in size.

About 75 percent of this soil is used for crops, and the remaining 25 percent is in range. Poor tilth and surface crusting and cracking are limitations to use. If the areas are not protected in winter, there is a slight hazard of soil blowing. Crops that mature in summer are frequently damaged because this soil is droughty. Capability unit IIIe–3; Clay Upland range site; not placed in a woodland suitability group; windbreak suitability group D.

Sogn Series

This series consists of shallow, nearly level to sloping, somewhat excessively drained soils on uplands. These soils formed in material weathered from limestone.

In a representative profile (fig. 10), the surface layer is very dark gray light silty clay loam about 7 inches thick. The underlying material is hard limestone.

Sogn soils have very low available water capacity and moderate permeability.

Representative profile of Sogn silty clay loam, in range, 1,380 feet north and 50 feet east of the southwest corner of sec. 27, T. 25 S., R. 6 E.:

A1—0 to 7 inches, very dark gray (10YR 3/1) light silty clay loam, black (10YR 2/1) when moist; strong, fine and medium, granular structure; slightly hard when dry; very friable when moist; many open pores; abundant roots; few small fragments of limestone; moderately alkaline; clear, smooth boundary.

R—7 inches, platy hard limestone, somewhat weathered at joints. Dark-colored material from the A horizon fills crevices in the bedrock to a depth of about 10 inches, but they make up less than 5 percent of the mass. A few grass roots penetrate crevices to a depth of about 18 inches.

The A1 horizon is silty clay loam or silt loam 4 to 20 inches thick. Its color ranges from dark gray to very dark grayish brown. Reaction of the A1 horizon is slightly acid to moderately alkaline. Coarse limestone fragments make up less than 35 percent of the soil mass. Depth to the R horizon ranges from 4 to 20 inches. The R horizon is thin, platy, or massive hard limestone.

Sogn soils are associated with the Clime, Florence, and Labette soils. They are less deep than the associated soils, and they lack a B2t horizon that is characteristic of these soils.

Sogn soils (0 to 8 percent slopes) (So).—Soils in this mapping unit are mostly on narrow divides on uplands.

Figure 10.—Typical profile of a Sogn silty clay loam.

They have a surface layer of silt loam or silty clay loam. The areas are irregular in shape. They range from 40 to 100 acres in size.

Included with these soils in mapping were a few small areas of Labette soils that make up less than 10 percent of the areas mapped. In some places bare limestone rock and shale are exposed.

These soils are not suitable for crops and nearly all of the acreage is used for range. Capability unit VIIs–1; Shallow Limy range site; not placed in a woodland suitability group; windbreak suitability group G.

Tully Series

This series consists of deep, gently sloping and sloping, well-drained soils on uplands. These soils formed in slope wash or colluvium.

In a representative profile the surface layer is very dark gray silty clay loam about 10 inches thick. The subsoil is about 54 inches thick. The upper 6 inches is firm, dark grayish-brown heavy silty clay loam. The next 36 inches is dark-brown and brown, firm silty clay. The lower layer is reddish-gray silty clay.

Tully soils have high available water capacity and slow permeability.

Representative profile of Tully silty clay loam, 4 to 7 percent slopes, in range, about 900 feet east and 50 feet north of the southwest corner of sec. 36, T. 28 S., R. 4 E.:

A1—0 to 10 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) when moist; strong, medium, granular structure; slightly hard when dry, friable when moist; few open pores; abundant roots; slightly acid; gradual, smooth boundary.

B1—10 to 16 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) when moist; strong, fine, subangular blocky structure; hard when dry, firm when moist; few open pores; thin continuous clay films; abundant roots; slightly acid; gradual, smooth boundary.

B21t—16 to 25 inches, dark-brown (7.5YR 4/3) silty clay, dark brown (7.5YR 3/2) when moist; moderate, fine, blocky structure; very hard when dry, firm when moist; few open pores; thin continuous clay films; few roots; slightly acid; gradual, smooth boundary.

B22t—25 to 52 inches, brown (10YR 5/3) silty clay, dark brown (10YR 4/3) when moist; weak, medium, blocky structure; very hard when dry, firm when moist; few open pores; few clay films; few small lime concretions; few fine black concretions; slightly acid; gradual, smooth boundary.

B3—52 to 64 inches, reddish-gray (5YR 5/2) silty clay, dark reddish-gray (5YR 4/2) when moist; weak, medium, blocky structure; extremely hard when dry, very firm when moist; few open pores; thin continuous clay films; neutral.

The A1 horizon is silty clay loam or heavy silt loam 7 to 14 inches thick. Its color ranges from very dark gray to very dark grayish brown. Reaction is medium acid to neutral. The B1 horizon is heavy silty clay loam or light silty clay 4 to 8 inches thick. Its color ranges from dark gray to very dark grayish brown. Reaction is medium acid to neutral. The B21t and B22t horizons are silty clay or light clay 30 to 45 inches thick. The color ranges from grayish brown to dark brown. Reaction is slightly acid to mildly alkaline. The B3 horizon is silty clay or light clay that ranges from grayish brown to reddish gray in color. Reaction is slightly acid to mildly alkaline. In some places the B3 horizon is mottled with brown, yellow, and reddish brown. In many places a few chert fragments are in the upper part of the solum, but they make up less than 5 percent of the soil mass.

Tully soils have a profile that is similar to that of the Labette, Norge, Irwin, and Vanoss soils. They are more clayey and less red in the B2t horizon than Norge soils. They are deeper and less red in the B2t horizon than Labette soils. Tully soils have a more gradual change between the A1 and B2t horizons than Irwin soils. Tully soils are more clayey in the B2t horizon than Vanoss soils.

In mapping unit Tt, the A1 horizon and the upper part of the B1 horizon are a few inches thinner than the minimum defined range for the series. This difference does not alter the behavior and usefulness of the soil.

Tully silty clay loam, 1 to 4 percent slopes (Ts).—This soil is mainly in valleys throughout the county. The areas are small, generally less than 60 acres in size. This soil formed in colluvium adjacent to intermittent streams, but above flood plains.

Included with this soil in mapping were a few small areas of Norge soils and Vanoss soils that make up less than 15 percent of the areas mapped. Small eroded areas are shown on the soil map by symbols. Each symbol represents an area 1 to 4 acres in size.

About half of the acreage of this Tully soil is cultivated, and half is used for range. This soil is easily worked and has no serious limitations. The water erosion hazard is slight. Runoff is medium. Capability unit IIe–2; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Tully silty clay loam, 3 to 6 percent slopes, eroded (Tt).—This soil formed in colluvial sediment close to intermittent streams, but above flood plains. Most areas are narrow and rectangular in shape and are less than

40 acres in size. This soil has a profile similar to that described as representative for the series, except that erosion has removed most of the original surface layer. The present surface layer is 4 to 7 inches thick. It consists mostly of dark grayish-brown or dark-brown heavy silty clay loam from the upper part of the subsoil. There is an abrupt boundary between the surface layer and the silty clay subsoil. Rills and a few gullies are evident around the heads of drainageways, and sheet erosion is common on the more uniform slopes.

Included with this soil in mapping were a few small areas of Tully soils that are not eroded and a few small areas of Norge silty clay loam. These inclusions make up less than 20 percent of the areas mapped.

Nearly all of this Tully soil is cultivated. Some areas, however, are reverting to range.

The main limitations to use of this soil are susceptibility to water erosion, rapid runoff, poor tilth, and low fertility. Capability unit IIIe-7; Clay Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Tully silty clay loam, 4 to 7 percent slopes (Tu).—This soil formed in colluvial sediment close to intermittent streams, but above flood plains. Most areas are long and narrow, and they range from 20 to 80 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping were a few small areas of Irwin and Norge soils. These inclusions make up less than 15 percent of the mapped acreage. Also included were a few small areas where the surface layer has been thinned by erosion, or it was never as thick as the surface layer in the profile described as representative of the Tully series. Small eroded areas are shown on the map by symbols. Each symbol represents an area about 1 to 4 acres in size.

Most of this Tully soil is in range, but a few areas are cultivated. If this soil is cultivated the main management concerns are controlling water erosion, reducing rapid runoff, and maintaining tilth and fertility. Capability unit IIIe-4; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Vanoss Series

This series consists of deep, nearly level and gently sloping, well-drained soils on uplands and terraces. These soils formed in loamy sediment of stream valleys and adjacent areas.

In a representative profile the surface layer is dark-gray silt loam about 12 inches thick. The subsoil is about 45 inches thick. The upper 6 inches is dark grayish-brown, friable light silty clay loam. The rest of the subsoil is brown, friable silty clay loam.

Vanoss soils have high available water capacity and moderate permeability.

Representative profile of Vanoss silt loam, 0 to 1 percent slopes, in a cultivated field, about 2,590 feet south and 50 feet east of the northwest corner of sec. 9, T. 28 S., R. 5 E.:

A1—0 to 12 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; moderate, fine, granular structure; slightly hard when dry, very friable when moist; numerous open pores; slight grayish coatings on peds in lower part; slightly acid; gradual, smooth boundary.

B1—12 to 18 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and very fine, subangular blocky structure; hard when dry, friable when moist; many open pores; slightly acid; gradual, smooth boundary.

B2t—18 to 35 inches, brown (7.5YR 5/3) silty clay loam, dark brown (7.5YR 4/3) when moist; strong, fine and very fine, blocky structure; hard when dry, friable when moist; many open pores; few, thin, patchy clay films; few very fine black concretions; slightly acid; gradual, smooth boundary.

B3—35 to 57 inches, brown (7.5YR 5/4) light silty clay loam, dark brown (7.5YR 4/4) when moist; weak, medium, blocky structure; hard when dry, friable when moist; few, thin, patchy clay films; few very fine black concretions; slightly acid.

The A1 horizon is silt loam or light silty clay loam and is 8 to 14 inches thick. Its color ranges from dark gray to very dark grayish brown. Reaction is slightly acid to medium acid. The B1 horizon is heavy silt loam or silty clay loam and is 4 to 8 inches thick. Its color is dark grayish brown to dark brown. Reaction is neutral to medium acid. The B2t horizon is silty clay loam and is 15 to 25 inches thick. Its color ranges from dark yellowish brown to brown. Reaction is neutral to medium acid. The B3 horizon is light silty clay loam or heavy silt loam, and it ranges from brown to yellowish brown in color. Reaction is neutral to medium acid.

Vanoss soils have a profile similar to that of the Norge, Tully, and Verdigris soils. They are less red in the B2t horizon than Norge soils. They are less clayey in the B2t horizon than Tully soils. Vanoss soils have a B2t horizon, which is lacking in Verdigris soils.

Vanoss silt loam, 0 to 1 percent slopes (Va).—This soil is mostly on valley terraces. The areas are irregular in shape and range from about 20 to 80 acres in size. This soil has the profile described as representative of the Vanoss series.

Included with this soil in mapping were a few small areas of Norge soils that make up less than 10 percent of the acreage of the mapped areas. Also included were a few areas where the lower part of the subsoil is mottled with reddish brown.

This Vanoss soil is easy to farm, and most of it is used for field crops. Runoff is slow, infiltration is good, and the erosion hazard is none to slight. This soil is well suited to all locally grown crops and grasses. If well managed, this soil can be cropped intensively. Capability unit I-1; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Vanoss silt loam, 1 to 3 percent slopes (Vb).—This soil is next to the nearly level Vanoss soils and along small intermittent drainageways. The areas are generally narrow and long and range from 20 to 60 acres in size. This soil has a profile that is similar to the one described as representative of the series, but the surface layer is 3 to 5 inches thinner and is dark grayish brown to dark gray.

Included with this soil in mapping were a few small areas of Norge and Tully soils. These inclusions make up less than 15 percent of the acreage in the mapped areas.

About half of this soil is cultivated. The rest is used for range. Soils in this unit are well suited to locally

grown field crops and grasses. Although runoff is medium and much of the rainfall is absorbed by the soil, water erosion is a hazard. Capability unit IIe-1; Loamy Upland range site; not placed in a woodland suitability group; windbreak suitability group C.

Verdigris Series

This series consists of deep, nearly level and gently sloping, moderately well drained soils on bottom lands. These soils formed in loamy alluvial sediment.

In a representative profile the upper part of the surface layer is dark grayish-brown silt loam about 8 inches thick, and the lower part is friable, dark-gray silty clay loam about 25 inches thick. The next layer is about 24 inches thick. It is friable, very dark grayish-brown silty clay loam that has common, fine, distinct mottles.

Verdigris soils have high available water capacity and moderate permeability.

Representative profile of Verdigris silt loam, in a cultivated field, about 1,340 feet south and 1,250 feet east of the northwest corner of sec. 31, T. 25 S., R. 6 E.:

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist; slightly acid; clear, smooth boundary.

A11—8 to 16 inches, dark-gray (10YR 4/1) silty clay loam, black (10YR 2/1) when moist; strong, fine, granular structure; slightly hard when dry, friable when moist; few worm casts; numerous open pores; slightly acid; gradual, smooth boundary.

A12—16 to 33 inches, dark-gray (10YR 4/1) silty clay loam, dark grayish brown (10YR 4/2) when crushed, black (10YR 2/1) when moist; strong, very fine, irregular, blocky structure that has a subangular blocky component; hard when dry, friable when moist; numerous open pores; slightly acid; gradual, smooth boundary.

AC—33 to 57 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) when moist; common, fine, distinct mottles of strong brown (7.5YR 5/6) when moist; moderate, fine, blocky structure; hard when dry, friable when moist; few open pores; slightly acid.

The Ap, A11, and A12 horizons are silt loam or silty clay loam, and the combined thickness is 20 to 35 inches. The color ranges from dark gray to very dark grayish brown. Reaction is slightly acid to medium acid. The AC horizon is silt loam or silty clay loam. Its color ranges from dark gray to very dark grayish brown. Reaction ranges from slightly acid to medium acid. In some places mottles of strong brown are below a depth of 30 inches.

Verdigris soils have a profile similar to that of Vanoss soils. They are associated with the Brewer and Osage soils. They lack the B2t horizon of Vanoss soils. They are coarser textured in all horizons than Brewer soils. Verdigris soils are coarser textured in all horizons than Osage soils and they are better drained.

Verdigris silt loam (0 to 3 percent slopes) (Vd).—This soil is on bottom lands throughout the county. The areas are irregular in shape. They range from about 20 to 400 acres in size. This soil has the profile described as representative of the series (fig. 11).

Included with this soil in mapping were a few small areas of Brewer silty clay loam. These areas are concave and they make up less than 15 percent of the acreage in the mapped areas. Included also were a few areas where the lower part of the soil is mottled in red.

Figure 11.—Typical profile of a Verdigris silt loam.

Except for the narrow, irregularly shaped areas adjacent to streams, most of this soil is cultivated. Runoff is slow. Although flooding occurs, serious damage to crops is infrequent. All locally grown crops, grasses, and trees are well suited to this soil. Practices that maintain productivity and soil structure can be carried out more easily on this soil than on most other soils in the county. Capability unit I-2; Loamy Lowland range site; woodland suitability group 1; windbreak suitability group A.

Verdigris soils, frequently flooded (0 to 3 percent slopes) (Ve).—These soils are on narrow flood plains that generally are about 100 to 800 feet in width, but in places they are about 200 feet in width. The narrow bottom lands are dissected by meandering stream channels and are frequently flooded (fig. 12). These soils have a profile that is similar to the one described as representative of the series, but in many places thin layers of recent deposits of silt loam or silty clay loam are on the surface.

Included with this soil in mapping were a few small areas of Tully and Verdigris soils and a few gravel bars. These inclusions make up less than 20 percent of the acreage in the mapped areas.

Figure 12.—Area of Verdigris soils, frequently flooded. Scouring and deposition have occurred where these soils have been farmed.

Nearly all of this soil is used for range or as habitat for wildlife. Because of frequent flooding and susceptibility to erosion, these soils are better suited to range than to field crops. Many areas are nearly inaccessible to farm machinery. Runoff is slow. Capability unit VIw-1; Loamy Lowland range site; woodland suitability group 1; windbreak suitability group A.

Use and Management of the Soils

This section has several main parts. In the first part, management needed for soils used for crops is discussed. Next, uses of the soils for range, as woodland, for windbreaks, and for wildlife habitat are described. Finally, soil interpretations for recreational uses are given, and engineering uses of the soils are explained. Additional information about the use and management of the soils in Butler County can be obtained from the local Soil Conservation Service technician or from the county extension agent.

Management of Soils Used for Crops [2]

This subsection mentions basic management practices needed for soils used for crops, explains the system of capability classification used by the Soil Conservation Service, and discusses use and management of the soils by capability units. It also provides a table of predicted average acre yields of the principal crops grown in the county under a high level of management.

Using and efficiently managing soils for field crops in Butler County can result in good returns over a period of years without lessening the productivity of the soils. If the soils are to be managed properly, each soil should be used for the crop or purpose for which it is best suited. Good management reduces losses of organic matter in cultivated soils. Good management of crop residue is important to the maintenance of good soil structure, infiltration, and percolation of water and to the reduction of erosion. Deep-rooted legumes, such as alfalfa and sweetclover, increase the intake of water. Varying the depth of tillage helps to prevent the formation of a plowpan.

If the soils are used for field crops, a system of management is needed that includes a suitable cropping system, minimum tillage, and optimum use of fertilizer and lime. All available manure and crop residue should be returned to the soil to maintain or to improve soil structure and tilth. Terracing and contour farming help to reduce erosion of sloping soils. Drainage is needed for some soils on bottom lands, and it is also needed for some soils on uplands. For most soils good management consists of a combination of practices.

Wheat, sorghum, alfalfa, soybeans, and corn are the crops commonly grown in Butler County. On most soils these crops respond well to the use of commercial fertilizer, lime, and manure. The kind and amount of fertilizer to use for each crop can best be determined by soil tests, field trials, and observation.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or engineering.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These levels are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

- Class I soils have few limitations that restrict their use.
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

[2] EARL J. BONDY, conservation agronomist, Soil Conservation Service, helped prepare this subsection.

- Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
- Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat. (None in Butler County.)
- Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.
- Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.
- Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, but not in Butler County, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-3 or IIIe-6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

For a complete explanation of the capability classification, see Agriculture Handbook No. 210 (*12*). In the following pages the capability units in Butler County are described and suggestions for the use and management of the soils are given. The names of soil series represented are mentioned in the description of each unit, but this dos not mean that all the soils of a given series are in the unit. The capability unit designation for each soil in the county can be found by referring to the "Guide to Mapping Units" at the back of this survey.

CAPABILITY UNIT I-1

This unit consists of deep, nearly level, well-drained soils of the Norge and Vanoss series. These soils formed in loamy sediment of stream valleys and adjacent uplands. Their surface layer is silt loam 9 to 12 inches thick. It is underlain by firm or friable silty clay loam. Soils of this unit have slow runoff and high available water capacity. Permeability is moderate and moderately slow.

The soils of this unit are easy to till. Maintenance of fertility and good tilth are the main management needs. Crops that produce an ample growth of leaves and stems can be grown year after year if the crop residue is returned to the soil. A winter cover crop is needed after silage crops are harvested, or after other crops that leave little residue are harvested.

These soils are well suited to all crops commonly grown in the county. Wheat, sorghum, soybeans, and alfalfa are the principal crops. These soils are also well suited to tame and native perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT I-2

This unit consists of deep, nearly level, moderately well drained soils of the Brewer and Verdigris series. They formed in clayey and loamy alluvial sediment and are on bottom land. The surface layer of these soils is 14 to 33 inches of silt loam or silty clay loam. It is underlain by very firm silty clay or friable silty clay loam.

Soils of this unit have slow runoff and high available water capacity. Permeability is moderate to slow.

In a few places these soils are flooded for short periods after heavy rain. Although some crop damage may result, the soils of this unit are among the best in the county for farming.

Crops that produce sufficient vegetative growth can be grown year after year if the crop residue is returned to the soil and weeds and insects are controlled. Good management of crop residue helps to increase the intake of water and improves tilth.

Soils of this unit are suited to all crops grown locally. Alfalfa, sorghum, corn, wheat, and soybeans are grown extensively. These soils are also well suited to native and tame perennial grasses, trees for windbreaks, woodland, and development of wildlife habitat.

CAPABILITY UNIT IIe-1

This unit consists of deep, gently sloping, well-drained soils of the Norge and Vanoss series. These soils formed in loamy sediment and are in stream valleys and adjacent uplands. Their surface layer is silt loam 9 to 12 inches thick. It is underlain by firm or friable silty clay loam.

Soils of this unit have medium runoff and high available water capacity. Permeability is moderate and moderately slow.

The soils of this unit are easy to till. Maintenance of good tilth and fertility and the control of erosion are the main management needs. Terracing and contour farming help to control erosion. Good management of crop residue

also helps to control erosion, increases the intake of water, and improves tilth.

The important crops grown on these soils are wheat, sorghum, soybeans, and alfalfa. These soils are also well suited to native and tame perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIe-2

Only Tully silty clay loam, 1 to 4 percent slopes, is in this unit. It is deep, gently sloping, and well drained. It formed in slope wash or colluvium, and it is in valleys. The surface layer of this soil is about 10 inches of silty clay loam. It is underlain by firm silty clay.

This soil has medium runoff, high available water capacity, and slow permeability. In most places runoff is received from higher areas.

The major management needs are the control of erosion and the maintenance of good tilth and fertility. Terracing and contour farming help to control erosion. Good management of crop residue also helps to control erosion, increases the intake of water, and helps to maintain good tilth.

This soil is well suited to all crops commonly grown in the county. Wheat, sorghum, soybeans, and alfalfa are the main crops. It is also well suited to native and tame perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIe-3

Only Labette silty clay loam, 1 to 3 percent slopes, is in this unit. This moderately deep, gently sloping, well-drained soil formed over limestone and shale and is on uplands. Its surface layer is silty clay loam about 13 inches thick. The subsoil is firm silty clay about 25 inches thick. It is underlain by limestone or shale.

This soil unit has medium runoff, low to moderate available water capacity, and slow permeability. The amount of water this soil can store is limited by the underlying limestone or shale. However, the stored water is readily available for use by plants.

Major management needs associated with this soil are the control of erosion and the maintenance of good tilth and fertility. Terracing and contour farming help to reduce water erosion. Good management of crop residue also helps to control erosion, increases the intake of water, and improves tilth.

Wheat and sorghum are the main crops grown on this soil. Corn and alfalfa are suited, but growth is often restricted during dry periods. This soil is also suited to native and tame perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIs-1

This unit consists of deep, nearly level, well-drained to somewhat poorly drained soils of the Goessel, Irwin, and Ladysmith series. These soils formed in clayey sediment and are on uplands. Goessel soils have a surface layer of silty clay about 18 inches thick. The next layer is very firm silty clay about 26 inches thick. The underlying material is very firm silty clay. The Irwin and Ladysmith soils have a surface layer of silty clay loam 8 or 9 inches thick. Below this layer is firm or very firm silty clay.

Soils of this unit have slow runoff and high available water capacity. Permeability is very slow.

Management is needed to maintain good soil structure, tilth, and fertility. Practices are also needed that increase the intake of water, especially in Goessel soils because they tend to crust and crack badly when dry, and they swell and become sticky when wet. Tillage must be done at the proper moisture content. Erosion is a hazard in areas adjacent to drainageways or in areas that are left bare in winter and in spring.

Wheat, sorghum, alfalfa, and soybeans are the main crops grown on these soils. Corn generally is not grown, because of summer droughts and the slow release of water by the clayey subsoil. These soils are also suited to native and tame perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIIe-1

This unit consists of deep, gently sloping, moderately well drained and well drained soils of the Goessel and Irwin series. These soils formed in clayey sediment and are on uplands. The Goessel soil has a surface layer of silty clay about 14 inches thick. The next layer is very firm silty clay about 26 inches thick, and the underlying material is very firm silty clay. The Irwin soil has a surface layer of silty clay loam about 11 inches thick. Below, to a depth of 42 inches, is firm and very firm silty clay.

Soils in this unit have medium runoff and high available water capacity. Permeability is very slow.

The soils of this unit are difficult to till, especially those of the Goessel series. They tend to crust and crack when dry, and they swell and become sticky when wet.

Management is needed to maintain soil structure and fertility and to increase the intake of water. Water erosion is a serious hazard, but soil blowing can also be a hazard if these soils are left bare in winter and in spring (fig. 13).

Figure 13.—Area of Irwin silty clay loam, 1 to 3 percent slopes, where damaging soil blowing has occurred. This soil is in capability unit IIIe-1.

Contour farming, terracing, and returning crop residue to the soil help to maintain good tilth and to control water erosion, soil blowing, and crusting. Deep-rooted legumes improve water intake.

Wheat, sorghum, alfalfa, and soybeans are the main crops. Corn generally is not grown on these soils, because of summer droughts and slow release of water by the clayey subsoil. These soils are also suited to native and tame perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIIe-2

Only Labette-Dwight complex, 1 to 3 percent slopes, is in this unit. These soils formed over limestone and shale and are on uplands. The Labette soil has a surface layer of silty clay loam about 13 inches thick. The upper part of the subsoil is about 5 inches of firm, light silty clay. The rest of the subsoil is about 20 inches thick and is firm silty clay. It is underlain by limestone or shale. The Dwight soil has a surface layer of silt loam about 5 inches thick. The subsoil is very firm silty clay about 28 inches thick. It is underlain by limestone or shale.

Soils of this unit have medium runoff and low to moderate available water capacity. Permeability is slow and very slow.

Major management needs are the control of erosion and the maintenance of fertility and good tilth. Crop growth and maturity is uneven because of the contrasting characteristics of these soils. Terracing and contour farming help to control erosion on these soils. Some farmers use a cropping system of 4 or 5 years of wheat followed by sweetclover. The sweetclover increases the intake of water and helps to maintain fertility and structure of the soil.

Wheat and sorghum are the main crops grown on these soils. Alfalfa, corn, and soybeans are not well suited, because of the low to moderate available water capacity. The soils of this unit are suited to native and tame perennial grass, trees for windbreaks, and limited development of wildlife habitat.

CAPABILITY UNIT IIIe-3

This unit consists of moderately deep, gently sloping, well-drained soils of the Labette and Rosehill series. These soils formed over limestone and shale and are on uplands. The Labette soil has a surface layer that has been thinned by erosion and is now a heavy silty clay loam about 5 inches thick. The subsoil is firm silty clay and silty clay loam about 25 inches thick. It is underlain by limestone or shale. The Rosehill soil has a silty clay surface layer about 9 inches thick. The next layer is firm silty clay about 18 inches thick. The underlying material is shaly clay.

Soils of this unit have medium runoff and low to moderate available water capacity. Permeability is slow and very slow.

The soils of this unit are difficult to work. Good tilth is difficult to maintain, especially in eroded areas where tillage extends into the clayey subsoil. These soils are sticky when wet and hard or very hard when dry. Tillage must be done at proper moisture content. The amount of water that the soils can store is limited by the underlying limestone or shale. Control of erosion and maintenance of good tilth and fertility are the main management needs if these soils are farmed.

Terracing and contour farming help to control erosion. Good management of crop residue aids in the control of erosion, increases the intake of water, and improves soil tilth.

These soils are suited to all crops commonly grown in the county, except corn. Alfalfa is often affected during dry periods because of limited available water capacity of the soil. These soils are also suited to native and tame perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIIe-4

Only Tully silty clay loam, 4 to 7 percent slopes, is in this unit. This deep, sloping, well-drained soil formed in slope wash or colluvium and is in valleys. The surface layer is silty clay loam about 10 inches thick. The upper 6 inches of the subsoil is firm silty clay loam. The lower part is firm silty clay.

This soil has rapid runoff and high available water capacity. Permeability is slow.

This soil is subject to severe water erosion if the areas are not protected. In most places it receives runoff from higher areas, and large amounts are received during heavy rains.

The main management needs include the control of erosion and the maintenance of good tilth and fertility. Terracing and contour farming help to control erosion. In places diversion terraces are needed to intercept water from higher areas. Good management of crop residue aids in the control of erosion, increases the intake of water, and maintains good tilth.

This soil is suited to all crops commonly grown in the county. Wheat, sorghum, soybeans, and alfalfa are the main crops. It is also well suited to native and tame perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIIe-5

Only Norge silt loam, 3 to 5 percent slopes, is in this unit. This deep, sloping, well-drained soil formed in loamy sediment. It is in stream valleys and on adjacent uplands. The surface layer of this soil is very friable silt loam about 7 inches thick. It is underlain by silty clay loam that is friable in the upper 9 inches and firm below.

This soil has rapid runoff and high available water capacity. Permeability is moderately slow.

This soil is easy to till, and it stores large amounts of water, which is readily available to plants. If it is cultivated and not protected, water erosion is a serious hazard because this soil tends to gully easily.

Good management practices help to control erosion and to maintain tilth and fertility. Terracing and contour farming help to control erosion. Good management of crop residue also aids in the control of erosion and helps to maintain good tilth.

This soil is suited to all crops commonly grown in the county. Wheat, sorghum, and alfalfa are the principal crops. It is also suited to tame and native perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIIe-6

Only Norge silty clay loam, 3 to 5 percent slopes, eroded, is in this unit. This deep, sloping, well-drained soil formed in loamy sediment, and it is in stream valleys and on adjacent uplands. The original surface layer of this soil has been thinned by erosion, and the present surface layer is only about 5 inches thick. It is underlain by firm silty clay loam.

This soil has rapid runoff and high available water capacity. Permeability is moderately slow.

This soil crusts easily, and in many places it puddles when wet. A few shallow gullies and rills have formed in some places. These conditions increase runoff and retard emergence of seedlings.

Major needs associated with this soil are the control of erosion and the maintenance or improvement of soil tilth and fertility. Terracing and contour farming help to control erosion. Good management of crop residue helps to keep the surface layer in good condition and also helps to control erosion.

The crops generally grown on this soil are wheat, sorghum, and alfalfa. This soil is also suited to native and tame perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIIe-7

This unit consists of deep, sloping, well-drained soils of the Irwin and Tully series. These soils formed in clayey sediment and are in stream valleys and on uplands. The Irwin soil has a surface layer of silty clay loam about 11 inches thick. This layer is underlain by firm silty clay. The original surface layer of the Tully soil has been thinned by erosion and the present surface layer is only 4 to 7 inches thick. The surface layer is underlain by firm silty clay.

Soils of this unit have rapid runoff and high available water capacity. Permeability is slow and very slow.

These soils store a large amount of water and release it slowly for plant use. The hazard of water erosion is severe. A few small gullies and rills form in most cultivated fields.

Terracing and contour farming help to control erosion on these soils. Management is needed that will maintain soil structure and adequate fertility and that will increase the intake of water. Deep-rooted legumes improve water intake. Properly managed crop residue also helps to reduce further erosion, increases water intake, and aids in maintaining good tilth.

Wheat and native grass are the main crops on these soils. These soils are also suited to tame grass, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIIe-8

Only Labette silty clay loam, 3 to 5 percent slopes, is in this unit. This moderately deep, sloping, well-drained soil formed over limestone and shale and is on uplands. The surface layer of this soil is silty clay loam about 13 inches thick. The subsoil is firm silty clay about 25 inches thick. It is underlain by limestone or shale.

This soil has rapid runoff and low to moderate available water capacity. Permeability is slow.

This soil takes in water readily if the surface is in good condition. The amount of water that this soil can store is limited by the underlying limestone or shale; however, the stored water is readily released to plants.

The major management needs are the control of erosion and the maintenance of fertility and good tilth. Terracing and contour farming help to reduce water erosion. Good management of crop residue also helps to control erosion, increases the intake of water, and helps to maintain good tilth.

Wheat and sorghum are the main crops. Such crops as corn and alfalfa are affected during dry periods.

Most of this soil is used for range, and it is well suited to this use. The soil is also well suited to tame perennial grass, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IIIw-1

Only Osage silty clay is in this unit. It is a deep, nearly level, poorly drained soil and is on bottom lands near major streams. It formed in clayey alluvial sediment. The surface layer is silty clay about 18 inches thick. It is underlain by firm silty clay.

This soil has slow runoff and high available water capacity. Permeability is very slow.

This soil takes in water slowly and releases it slowly for plant use. It floods occasionally. It is slow to warm up in spring, and tillage is often delayed because of wetness. In dry periods this soil is somewhat droughty; wide cracks develop, and tillage is difficult.

A system of open ditches and bedding improves surface drainage. Rough fall plowing aids in aeration of this soil. Good management of crop residue helps the surface layer to take in more water and helps prevent soil blowing in spring.

This soil is suited to most crops grown in the county, except alfalfa and corn. Wheat, sorghum, and soybeans are the main crops. Alfalfa is commonly short lived on this soil, and stands usually thin out, or completely disappear within 2 or 3 years. If an adequate drainage system is installed and maintained, alfalfa can be a dependable crop. This soil is also suited to tame and native perennial grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IVe-1

Only Irwin silty clay loam, 2 to 5 percent slopes, eroded, is in this unit. This deep, sloping, well-drained soil formed in clayey sediment and is on uplands. The original surface layer has been thinned by erosion, and the present surface layer is about 5 inches thick. It is underlain by firm silty clay.

This soil has rapid runoff and high available water capacity. Permeability is very slow.

This soil stores a large amount of water, but it releases water slowly for plant use. It is difficult to till, and surface crusts often hinder the emergence of seedlings. The water erosion hazard is severe on this soil, and gullies and rills form in a few places.

Terraces and contour farming help control erosion. Deep-rooted legumes improve the water intake capability of this soil. Good management of crop residue helps reduce erosion, increases the intake of water, and aids in maintaining good tilth. Fertility needs to be improved in most areas.

Wheat is the main crop grown on this soil. Some alfalfa and sorghum are also grown. This soil is also suited to native and tame grasses, trees for windbreaks, and development of wildlife habitat.

CAPABILITY UNIT IVs-1

Only Dwight silt loam, 0 to 2 percent slopes, is in this unit. The moderately deep, nearly level and gently sloping, moderately well drained soil formed in clayey sediment over limestone and shale. It is on uplands. The surface layer is silt loam about 5 inches thick. Below this layer is very firm silty clay. This soil is underlain by limestone or shale at a depth of about 33 inches.

This soil has medium to rapid runoff and low to moderate available water capacity. Permeability is very slow.

This soil takes in water very slowly and loses much water by runoff. The amount of water that this soil can store is limited by the underlying limestone or shale. Some surface crusting is evident in most cultivated areas. Droughtiness is common during periods of low rainfall. Erosion is a hazard where slopes are more than 1 percent.

The major management needs are maintaining fertility and good soil tilth. Good management of crop residue aids in maintaining good tilth and fertility, reduces crusting, and increases the intake of water. Deep-rooted legumes improve the water intake capability of this soil. Terraces can be used, where needed, to help to reduce erosion.

This soil is better suited to wheat than to other field crops. Some alfalfa, sweetclover, fescue, and sorghum are also grown. Corn, sorghum, soybeans, and smooth brome generally are not grown, because of summer droughts and the slow release of water by the silty clay subsoil. This soil is also suited to drought-tolerant, native and tame perennial grasses, to some kinds of trees for windbreaks, and to limited development of wildlife habitat.

CAPABILITY UNIT VIe-1

Only Labette-Sogn complex, 2 to 8 percent slopes, is in this unit. These soils are gently sloping and sloping and are on uplands. They formed over limestone and shale. The moderately deep, well-drained Labette soil has a surface layer of silty clay loam about 18 inches thick. The subsoil is firm silty clay about 25 inches thick. The shallow, somewhat excessively drained Sogn soil has a surface layer of silty clay loam, about 7 inches thick, that overlies limestone.

Soils in this unit have medium to rapid runoff. Available water capacity is very low to moderate, and permeability is moderate. In many places limestone fragments and rock outcrops are numerous.

These soils take in water readily if the surface has an adequate cover of vegetation. The amount of water stored in these soils is limited by their depth over limestone. These soils are subject to water erosion if the surface is exposed by fire or overgrazing. Grazing management helps maintain or improve the grasses and helps to control erosion.

Nearly all of the areas of these soils are used for range. Because of stones and rock outcrops, most areas cannot be tilled to establish grasses. These soils are also suited to trees for windbreaks and wildlife habitat development.

CAPABILITY UNIT VIe-2

This unit consists of deep and moderately deep, gently sloping to strongly sloping, well-drained soils of the Benfield, Florence, Labette, Olpe, and Norge series. These soils have a surface layer of silt loam, silty clay loam, cherty silty clay loam, or cherty silt loam. The subsoil is silty clay loam, silty clay, cherty silty clay, or cherty clay.

The soils in this unit have medium to rapid runoff and low to high available water capacity. Permeability is moderately slow to slow.

Soils of this unit take in water readily if the surface has a good cover of vegetation. The amount of water that some of these soils can store is limited by their content of chert fragments and by the depth of the chert. Erosion is a hazard on these soils if the surface layer is exposed by fire or is overgrazed. The presence of chert and an uneven relief preclude normal tillage.

The major use of the soils in this unit is for range. These soils are also suited to trees for windbreaks and development of habitat for wildlife.

CAPABILITY UNIT VIe-3

Only Clime-Sogn complex, 3 to 15 percent slopes, is in this unit. These soils are sloping to strongly sloping and are on uplands. They formed over limestone and calcareous shale. The moderately deep, moderately well drained to well drained Clime soil has a surface layer of silty clay about 9 inches thick. This layer is underlain by very firm silty clay. The shallow, somewhat excessively drained Sogn soil has a surface layer of silty clay loam about 7 inches thick. The surface layer rests directly on limestone.

For the soils of this unit, runoff is medium to rapid, depending on the slope. Available water capacity is very low to moderate, and permeability is moderate to moderately slow. Soils in this unit have numerous limestone fragments and exposed rock outcroppings.

Most areas of these soils cannot be tilled to establish grasses, because of stones, rock outcrops, and steepness of slope. The soil takes in water readily if the surface layer has a good cover of vegetation. The amount of water that these soils can store is limited by the depth of the soil over limestone or shale. These soils are susceptible to erosion if the surface is exposed by fire or overgrazing.

Nearly all of the acreage in this unit is used for range. These soils are also suited to trees for windbreaks and habitat for wildlife.

CAPABILITY UNIT VIe-4

Only Dwight soils, 1 to 2 percent slopes, eroded, are in this unit. These moderately deep, moderately well drained soils formed in clayey sediment over limestone and shale and are on uplands. The surface layer has been thinned by erosion, and the plow layer is heavy silty clay loam or silty clay. The subsoil is very firm silty clay. It is underlain by limestone or shale at a depth of about 33 inches.

Soils of this unit have medium to rapid runoff and low to moderate available water capacity. Permeability is very slow.

The soils of this unit crack when dry, and they swell when wet. Also, they are droughty and crust badly. Seed-

lings have difficulty emerging through this crust. A few shallow gullies and rills have formed in most areas.

Range management that includes control of grazing and protection of the areas from fire is needed to help control further erosion and to maintain desirable plant species.

These soils are better suited to range or to pasture than to field crops. If they are used for range or pasture, careful management is needed to maintain desired species. Smooth brome is a low producer of forage on these soils because of poor soil-plant relationships. Fescue and perennial native grasses tolerate these conditions better than other forage plants. These soils are also suited to trees for windbreaks and habitat for wildlife.

CAPABILITY UNIT VIw–1

Only Verdigris soils, frequently flooded, is in this unit. These deep, nearly level, moderately well drained soils formed in loamy alluvial sediment and are on flood plains. The surface layer of these soils is silt loam and silty clay loam about 33 inches thick. It is underlain by friable silty clay loam.

Soils of this unit have slow runoff and high available water capacity. Permeability is moderate.

These soils are frequently flooded, and if cropped they are subject to severe erosion. Most areas are dissected by stream channels, and many areas are nearly inaccessible to farm machinery. Soils in this unit take in water readily, store large amounts of water, and release it readily for plant use. Most areas of these soils cannot be tilled to establish grasses, because of frequent flooding and stream channel erosion.

Soils in this unit are better suited to range than to field crops. They are also suited to trees for windbreaks, woodlands, and habitat for wildlife.

CAPABILITY UNIT VIIs–1

Only Sogn soils are in this unit. These shallow, nearly level to sloping, somewhat excessively drained soils formed over hard limestone and are on uplands. The surface layer is silt loam or silty clay loam about 7 inches thick. It is underlain by hard limestone.

Runoff on soils of this unit is medium to rapid, and available water capacity is very low. Permeability is moderate.

The amount of water stored by these soils is limited because of their shallow depth. Many areas of these soils contain limestone fragments and outcrops. Soil erosion is a hazard if the surface layer is exposed by fire or overgrazing.

The soils in this unit cannot be tilled to establish grasses, because of many rock fragments and the shallow depth. Good grazing management helps maintain or improve the grasses and helps to control erosion.

Soils in this unit are better suited to range than to field crops. They are also suited to trees for windbreaks and habitat for wildlife.

CAPABILITY UNIT VIIIs–1

Only Oil-waste land is in this unit. This land type is only in the oil fields of the county. The characteristics are too variable to estimate, but all are affected by salt or oil. Most areas are either in or adjacent to drainageways.

The areas of Oil-waste land have been used as disposal fields for waste oil and salt water from oil wells and drilling operations. Most of them are so severely affected that very little vegetation can grow. This land has no value for crops or for range. In places some of the less sloping and less severely eroded areas can revegetate naturally if no more waste is dumped on them.

Predicted yields

Predicted yields per acre of the principal crops grown on arable soils in Butler County are given in table 2. The yields are estimated averages for a period long enough to include both good and bad years. Yields are considerably higher than these averages in years when temperature and moisture conditions are favorable and lower in years when temperature and moisture conditions are unfavorable.

Long-time records are not available, therefore the yields were made on the basis of data obtained from farmers, agricultural technicians, the Kansas Agricultural Experiment Station, and the observations of the soil survey party. No yields are given for soil normally considered unsuited for crops.

Yields given in table 2 are those that can be expected under a high level of management. This management includes the following:

1. Crop varieties used are suited to the area.
2. Proper seeding rates are used, and methods of planting and harvesting are suitable and timely.
3. Weeds, insects, and plant diseases are controlled sufficiently to insure normal plant growth.
4. Optimum amounts of fertilizer and lime as indicated by soil tests are used.
5. Applicable soil- and water-conserving practices are used, such as terraces, grassed waterways, and contour farming.
6. Surface drainage is established where needed.
7. Residue management and tillage methods designed to control erosion, preserve soil structure, increase intake of water, and favor seedling emergence are used.
8. A cropping system is used that helps keep the soil in good condition.

In estimating yields, consideration was given only to those crop varieties that were currently available. Corn and grain sorghum yields were based on the use of the better hybrids. Wheat, soybeans, and alfalfa yields were based on varieties available at the time estimates were made.

Range Management [3]

This subsection describes the grouping of soils in range sites and discusses the use and management of soils by range sites.

Approximately 58 percent of the acreage in Butler County is in native grass, generally called rangeland. This area supports the livestock industry in Butler County. Normally, between 135,000 and 150,000 cattle are grazed on the range. Sales of livestock and livestock

[3] By LEONARD JURGENS, range conservationist, Soil Conservation Service.

TABLE 2.—*Predicted average acre yields of the principal crops grown on arable soils under a high level of management*

[Absence of an entry in a column indicates that the crop is not suited to the soil or is not commonly grown on it]

Soil	Corn	Grain sorghum	Soybeans	Wheat	Alfalfa
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Tons*
Brewer silty clay loam	70	78	32	44	4.5
Dwight silt loam, 0 to 2 percent slopes		36		26	1.6
Goessel silty clay, 0 to 1 percent slopes	42	60	24	36	3.0
Goessel silty clay, 1 to 3 percent slopes	42	56	22	34	2.6
Irwin silty clay loam, 0 to 1 percent slopes	44	60	26	36	3.4
Irwin silty clay loam, 1 to 3 percent slopes	42	58	24	36	3.0
Irwin silty clay loam, 3 to 5 percent slopes	38	54	20	32	2.6
Irwin silty clay loam, 2 to 5 percent slopes, eroded		48	18	26	2.2
Labette silty clay loam, 1 to 3 percent slopes	45	66	25	36	2.6
Labette silty clay loam, 1 to 3 percent slopes, eroded		56	20	28	1.8
Labette silty clay loam, 3 to 5 percent slopes	40	62	22	32	2.6
Labette-Dwight complex, 1 to 3 percent slopes	33	52	18	34	1.8
Ladysmith silty clay loam, 0 to 2 percent slopes	44	56	22	34	3.0
Norge silt loam, 0 to 1 percent slopes	68	80	30	44	4.5
Norge silt loam, 1 to 3 percent slopes	62	76	26	42	4.0
Norge silt loam, 3 to 5 percent slopes	54	72	25	40	3.3
Norge silty clay loam, 3 to 5 percent slopes, eroded	52	66	21	36	3.1
Osage silty clay	45	60	27	32	2.8
Rosehill silty clay, 1 to 3 percent slopes		46	22	32	1.8
Tully silty clay loam, 1 to 4 percent slopes	54	80	28	40	3.5
Tully silty clay loam, 3 to 6 percent slopes, eroded		60	18	28	2.5
Tully silty clay loam, 4 to 7 percent slopes	46	76	25	36	3.0
Vanoss silt loam, 0 to 1 percent slopes	70	84	33	44	4.8
Vanoss silt loam, 1 to 3 percent slopes	62	80	26	42	4.0
Verdigris silt loam	77	80	36	46	5.0

products account for about 60 percent of the farm income in the county.

Livestock that graze the range in Butler County consist mainly of herds of cows and calves, but herds of yearlings are also common throughout the county. Forage from cropland and tame pasture is utilized by many farmers and ranchers to supplement forage produced on the range. Deer, prairie chicken, and other kinds of wildlife, in addition to domestic livestock, also depend on rangeland for their survival.

Three major grassland-soil associations are in the county. Along the eastern side of the county is part of the famous Flint Hills region. Here the tall grasses big bluestem, indiangrass, and switchgrass and the midgrass little bluestem are dominant on the cherty Florence soils and on the Labette soils. On the associated thin-surface layered Dwight soils and on the shallow Sogn soils, the mid grasses little bluestem and side-oats grama and the short grasses blue grama and buffalograss are the dominant vegetation.

The second major grassland-soil association, in the western side of the county, contains a significant part of the soils that make up the Clay Upland range site. This range site is an excellent producer of forage. The soils tend to fluctuate more in production between years of favorable and unfavorable moisture than those in the Loamy Upland range site.

The third grassland-soil association is along the major drainage system in the county. The soils that make up this site formed in alluvial and colluvial material. Before this county was settled, these soils were primarily in tall grasses. Woody vegetation, consisting mainly of walnut and bur oak, grew along the streams. Such cool-season grasses as Canada wildrye and Virginia wildrye grew under the trees. Now a large part of the acreage is farmed, but numerous areas have been retained in native vegetation that is cut for hay or is used for range (fig. 14).

Range sites and condition classes

To manage his range well and to use the range to best advantage, the rancher should know the different kinds of soil in his holdings, the location of each kind of soil, and the kinds and amounts of vegetation that can be grown on each. He can then regulate grazing so that the vigor and abundance of the best grasses are increased.

***Figure 14.*—Relic area of tall grasses on a Verdigris silt loam. Big bluestem is the dominant grass. Bur oak is the dominant species of tree in the background.**

The basic unit on which management of the range is determined is the range site. A *range site* is an area of range uniform enough in climate, soils, drainage, exposure, and relief that it produces a specific kind and amount of vegetation. The kind of vegetation, in most instances, is the combination of plants that grew on the site before the range was affected by grazing or cultivation and is called the potential or climax vegetation. Generally, the climax vegetation is the most productive combination of range plants that a site can support. The climax vegetation, or plant community, remains on the site if it is not disturbed by fire, excessive grazing, insects, or plant diseases.

Range condition is the state and health of the range based on what it is naturally capable of producing. A series of four categories is used to classify range condition. They are *excellent*, *good*, *fair*, and *poor*. Excellent condition means that 76 to 100 percent of the climax vegetation is present. Good means that 51 to 75 percent of the climax vegetation remains. Fair means that only 26 to 50 percent of the climax vegetation is present. Poor means that 25 percent or less of the climax vegetation remains.

Range condition declines through overgrazing or excessive mowing. Where this occurs, production of forage is reduced. Droughts hasten the decline of range that has been overgrazed or excessively burned. Fortunately, the decline can be reversed. Range sites can be brought back to excellent condition and maintained if proper range use and proper management are practiced.

Livestock graze vegetation selectively. They constantly seek the most palatable forage. If the amount of grazing is not regulated, the better plants are heavily utilized, become weakened, and decrease in abundance. Plants less preferred by livestock tend to increase. Consequently, plants are classified according to their response to continuous overgrazing.

Range plants are grouped into three categories called *decreasers*, *increasers*, and *invaders*. Figure 15 gives a general representation of what happens to plants that are overgrazed. Rangeland in excellent condition or near climax supports vegetation made up primarily of decreasers and some increasers. Invaders are plants that normally are not present on land in climax condition.

Decreasers are plants that will be grazed too closely by livestock when overgrazing is practiced. These generally

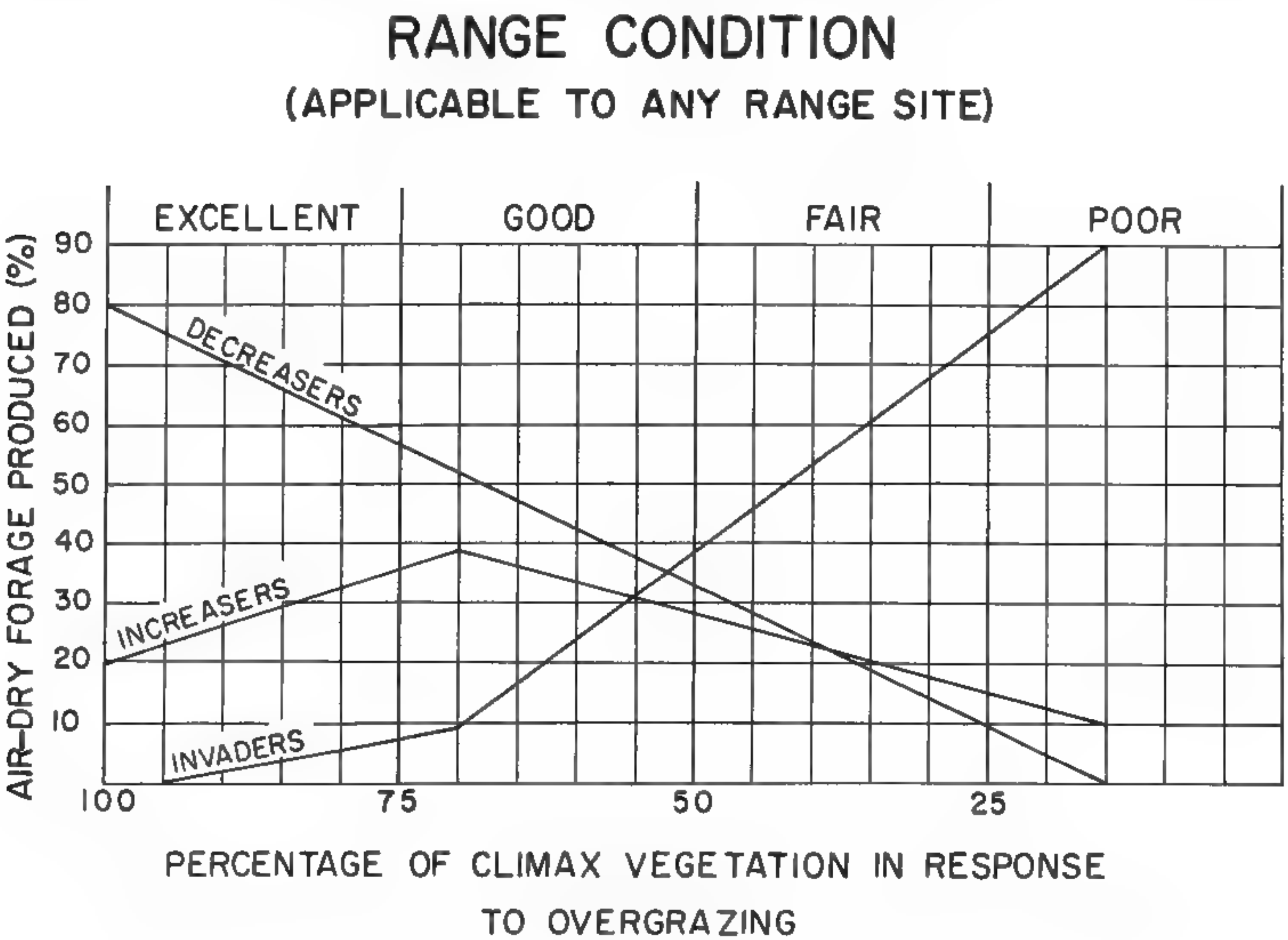

Figure 15.—A schematic presentation showing how decreasers, increasers, and invaders respond to overgrazing.

are the grasses and forbs that are the most productive as well as the most palatable to livestock.

Increasers are plants that produce some forage, but usually are less palatable to livestock than decreasers. These plants increase under overgrazing at the expense of the decreaser plants. With continued overgrazing the increasers will also be overgrazed and replaced by invader plants.

Invaders are plants that cannot survive under the intense competition of the decreasers and increasers when the range is at or near climax condition. However, when the competition of the decreasers and increasers is reduced by overgrazing and occasionally by severe drought, these invader plants rapidly appear and fill in the voids in the plant community. Most species of invaders have little or no grazing value in this area.

A range site in excellent condition produces the maximum amount of available forage for use by livestock and wildlife. In addition, soil and water conservation objectives are met when a range site is kept in excellent condition. Range management techniques are available to assist landowners and operators in applying practices that can return rangeland to excellent condition and maintain it.

Proper use and grazing distribution are two practices needed to maintain all range sites in the county. Improvement of a range site that is down in condition can be obtained by range deferment, rotation grazing, and brush and weed control.

Cropland and formerly cultivated land can be reestablished to productive rangeland by seeding the proper mixture of native grasses. Selected strains of native grass seeds are available. These strains give excellent results when used in their adapted area. Brush control is needed mainly where excessive grazing and improper use of fire have allowed brush and weed trees to dominate.

Descriptions of range sites

The native vegetation in Butler County consists mainly of tall and mid grasses, associated forbs, and some shrubs. The major range sites are Loamy Upland, Clay Upland, and Claypan. These sites comprise 35, 25, and 20 percent, respectively, of the total rangeland in the county. The remaining range sites, in the order of importance, are Loamy Lowland, Shallow Limy, Limy Upland, and Clay Lowland. Figure 16 shows major soils in the range sites in Butler County and the position on the landscape they commonly occupy.

Table 3 shows the air-dry yields of forage from stated range sites in excellent condition. Average yields are shown, as well as high yields and low yields that can be expected between favorable years and unfavorable years. In most years the yields are between the high and low values, depending on the vigor of the vegetation and the availability of moisture.

The range sites in Butler County are described in the paragraphs that follow. The names of the soil series represented are mentioned in the description of each range site, but this does not mean that all the soils of a given series are in the range site. The range site for each soil in the county can be found by referring to the "Guide to Mapping Units" at the back of this survey.

CLAYPAN RANGE SITE

In the Claypan range site are nearly level or gently sloping Dwight and eroded Irwin soils on uplands. These soils are moderately deep or deep. They have a surface layer of silt loam or heavy silty clay loam 3 to 7 inches thick, and a subsoil of dense silty clay. The dense subsoil retards the penetration of moisture and the development of roots. The Irwin soil is eroded.

During seasons of abundant rainfall, water frequently stands in depressions in this range site for long periods. The dense subsoil restricts the movement of moisture

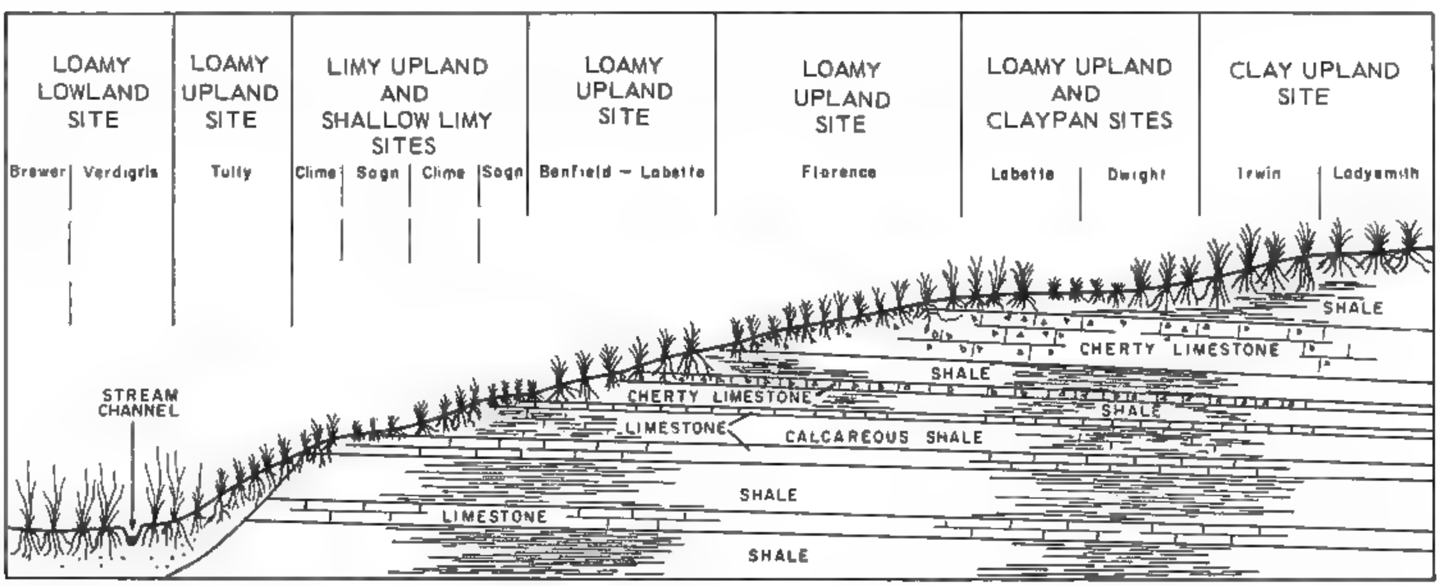

Figure 16.—Range sites in Butler County and major soils in each range site. Because of its minor extent, the Clay Lowland site is not shown.

TABLE 3.—*Total annual yield of forage per acre by range sites*

[Pounds, air-dry basis]

Range site	Average	High	Low
Claypan	2, 500	4, 000	1, 000
Clay Lowland	7, 500	10, 000	3, 000
Clay Upland	4, 700	8, 000	2, 000
Limy Upland	3, 000	4, 000	2, 000
Loamy Lowland	8, 000	10, 000	6, 000
Loamy Upland	5, 000	6, 500	3, 500
Shallow Limy	2, 700	3, 500	2, 000

into the soil. These soils do not release moisture readily to plants. This slow intake and release rate of moisture cause this site to be droughty and low in forage production. In addition, this range site is frequently overgrazed.

Where climax vegetation is dominant, as much as 60 percent or more of the total amount of forage is produced by side-oats grama, switchgrass, and little bluestem, which are decreasers. The rest is produced by blue grama, buffalograss, tall dropseed, western wheatgrass, slimflower scurfpea, heather aster, dotted gayfeather, and western ragweed, which are increasers.

Where the range is overgrazed, buffalograss, blue grama, tall dropseed, western ragweed, slimflower scurfpea, and dotted gayfeather and, occasionally, western wheatgrass become the dominant species.

Where this range site is in poor condition, annual three-awn, annual dropseed, and annual broomweed, which are invaders, and blue grama, buffalograss, and tall dropseed, which are increasers, occupy the site. Areas of abandoned cropland commonly have a cover of annual invaders and a few perennial increasers.

Areas of this range site that have been reduced to poor condition can be restored to production through range seeding. This range site responds slowly to good management practices, compared with other range sites in the county. Extra care is needed to maintain and improve condition of the range.

CLAY LOWLAND RANGE SITE

Osage silty clay is the only soil in the Clay Lowland range site. It is in nearly level areas or in slight depressions on flood plains. This soil is deep, poorly drained, and has very slow internal drainage. When dry, it becomes quite hard, and large deep cracks appear.

In excellent range condition, prairie cordgrass, big bluestem, indiangrass, sedges, and switchgrass produce most of the forage. Prairie cordgrass frequently dominates in the wetter parts of this site and produces more than 50 percent of the forage. Major increasers on this site are tall dropseed, sedges, ironweed, switchgrass, and western wheatgrass. Principal invaders are barnyardgrass, tumblegrass, weed trees, annual three-awn, giant foxtail, and Kentucky bluegrass. Where the range condition is poor, tall dropseed, sedges, barnyardgrass, tumblegrass, Kentucky bluegrass, Osageorange and other weed trees are the dominant vegetation.

Where the range has been depleted, brush control and deferred grazing can be effective in restoring this site to excellent range condition. If the decreaser species have been eliminated, range seeding helps restore the site. Better stands of native grasses are obtained if cover crops are planted 2 or more years prior to seeding. Weed-control measures after seeding are helpful in obtaining good stands.

During wet periods, mechanical operations are often delayed as much as several months. Surface water standing in depressions moves very slowly into the soil. Prairie cordgrass and sedges are tolerant of this wetness and, once established, produce excellent amounts of forage.

CLAY UPLAND RANGE SITE

In the Clay Upland range site are nearly level to sloping soils of the Goessel, Irwin, Ladysmith, and Rosehill series and eroded soils of the Tully and Labette series. These soils are moderately deep or deep. They have a silty clay or silty clay loam surface layer over a silty clay or clay subsoil. These soils have a low to high available water capacity. In years of adequate moisture and well distributed rain, this range site is among the most productive upland sites in the county (fig. 17). However, these soils are droughty during hot, dry seasons, and vegetation does not receive enough water to maintain growth.

Where the climax range is dominantly vegetation, most of the forage production comes from big bluestem, little bluestem, indiangrass, switchgrass, and leadplant amorpha, which are decreasers. Side-oats grama, tall dropseed, blue grama, slimflower scurfpea, and western ragweed, which are increasers, produce the rest of the forage. Invaders on this site are annual bromes, annual three-awn, buckbrush, and broomweed.

Where the range site is in poor condition, tall dropseed, slimflower scurfpea, western ragweed, and annual grasses commonly dominate.

Many areas of abandoned cropland are included in this range site. These areas can be economically restored to production through range seeding. Where buckbrush has become abundant, brush control is essential to improve production.

Figure 17.—**Steers on an area of Clay Upland range site in excellent condition. The soil is an Irwin silty clay loam.**

LIMY UPLAND RANGE SITE

The Limy Upland range site consists of Clime silty clay. Figure 16 shows the profile of soils in this range site. This Clime soil is moderately deep over calcareous shale. It is calcareous within 10 inches of the surface and has no more than a moderate supply of moisture for plant growth. However, growth is somewhat restricted by limited soil depth and low to moderate available water capacity.

Where this site has climax vegetation, more than 80 percent of the annual yield is produced by decreaser species. As much as 25 percent of this yield comes from forbs and shrubs. Decreasers are little bluestem, big bluestem, indiangrass, Jersey-tea, black samson, Maximilian sunflower, and prairie clovers. Side-oats grama, hairy grama, willowleaf sunflower, western ragweed, Missouri goldenrod, and dotted gayfeather increasers produce the rest of the forage. Where the range is overgrazed, invaders are annual bromes, broomweed, and annual three-awn. If range is in poor condition, most of the annual yield comes from annual grasses and forbs, increaser forbs, side-oats grama, and hairy grama.

In most places deferred grazing is the best method of restoring this site to excellent condition.

LOAMY LOWLAND RANGE SITE

The Loamy Lowland range site is made up of nearly level soils on lowlands and gently sloping soils along drainageways. These soils are of the Brewer and Verdigris series. They receive additional moisture from flooding and runoff water from adjacent side slopes. The soil has a high available water capacity. Because of its accessibility and proximity to watering facilities, most of this range site is in only fair condition (fig. 18).

Where this site has climax vegetation, decreasers produce more than 80 percent of the yield. Because of excellent moisture conditions, trees grow in most areas adjacent to the stream channel. Decreasers in this site are big bluestem, indiangrass, switchgrass, eastern gamagrass, wholeleaf rosinweed, compassplant, and sawtooth sunflower. Principal increasers are little bluestem, tall dropseed, side-oats grama, sedge species, ironweed, western ragweed, and buckbrush. Where continued overgrazing is practiced, invaders that move in are barnyard grass, annual bromes, Kentucky bluegrass, and such weed trees as osageorange and locust.

Figure 18.—Area of Verdigris soils, frequently flooded, in the Loamy Lowland range site. This range site is in fair condition. Ironweed is the principal broadleaf plant in the foreground.

Where the range condition is poor, tall dropseed, buckbrush, western ragweed, ironweed, Kentucky bluegrass, barnyardgrass, annual bromes, and weed trees are dominant.

Brush control is needed in many areas where buckbrush and weed trees grow. Where the range site is in poor condition, it can be effectively restored if adequate weed-control measures are used during stand establishment.

This range site is the most productive in the county. For maximum production this site should be fenced and managed separately, where feasible.

LOAMY UPLAND RANGE SITE

The Loamy Upland range site is made up of nearly level to strongly sloping soils of the Benfield, Florence, Labette, Norge, Olpe, Tully, and Vanoss series. These are moderately deep or deep soils that have a granular surface layer. They have a low to high available water capacity and a good water-to-plant relationship.

The Florence and Olpe soils in this site have a high proportion of chert throughout their profile, but the chert does not inhibit normal root development. Soils in this site often occur as parts of soil complexes in other range sites. Soils in one of the major soil complexes in Butler County are in the Loamy Upland and Shallow Limy range sites. Figure 19 shows a landscape where two soils in complexes are in the Loamy Upland range site, one is in the Shallow Limy range site, and one is in the Limy Upland range site.

Where the range site has climax vegetation, more than 80 percent of the production is from decreaser plants that include big bluestem, little bluestem, indiangrass, switchgrass, leadplant amorpha, roundhead lespedeza, and prairie clovers. Increasers, which are present in small quantities, are side-oats grama, tall dropseed, blue grama, smooth sumac, and western ragweed. Where the site is overgrazed, these increasers spread rapidly, and the invaders annual three-awn, annual bromes, broomweed, buckbrush, and Kentucky bluegrass appear.

Where the range condition is poor, annual grasses, broomweed, tall dropseed, buckbrush, sumac, western ragweed, and Kentucky bluegrass produce most of the vegetative cover.

On abandoned cropland in this range site, reseeding is the most effective method of restoring productivity. In overgrazed areas where decreaser plants have survived in adequate quantities, deferred grazing and brush-control practices are helpful in restoring the range.

SHALLOW LIMY RANGE SITE

In the Shallow Limy range site are mainly Sogn soils. Most of these soils occur as narrow bands on rolling uplands, where they are associated with soils in the Loamy Upland and Limy Upland range sites. A few

Figure 19.—**View of Loamy Upland, Limy Upland, and Shallow Limy range sites. The Benfield and Labette soils in the foreground and on caps of hills in the background are in the Loamy Upland range site. The Clime soils, in Limy Upland range site, and the Sogn soils, in Shallow Limy range site, occupy the lower two-thirds of the valley.**

broad areas of nearly level Sogn soils are on Uplands. Sogn soils typically range from 4 to 20 inches deep over platy or massive limestone beds. These soils have very low available water capacity and a shallow root zone that inhibits the normal development of most plant roots.

Where the range has climax vegetation, decreasers produce as much as 60 percent of the total yield. Side-oats grama, little bluestem, willowleaf sunflower, black samson, and prairie clovers are the principal decreasers. Some of the increasers that produce the rest of the yield are blue grama, hairy grama, buffalograss, smooth sumac, and dogwood. Invaders consist mainly of annual bromes, annual three-awn, and annual broomweed.

Where the range is in poor condition, the dominant vegetation is hairy grama, buffalograss, blue-grama, annual broomweed, annual three-awn, and annual bromes.

Use of Soils as Woodland and for Windbreaks [4]

In this subsection the soils of Butler County are discussed on the basis of their suitability for use as woodland and for farmstead windbreaks. The soils are placed in two woodland suitability groups, the soil-related factors are rated, and the suitable tree species are given for each group. Following the discussions of the woodland suitability groups, trees and shrubs suitable for farmstead windbreaks are discussed in seven broad groups of soils, the windbreak suitability groups. The names of soil series represented are mentioned in the description of each woodland suitability group and windbreak suitability group, but this does not mean that all the soils of a given series are in the group. The soils in each woodland suitability group and in each windbreak suitability group can be identified by referring to the "Guide to Mapping Units" at the back of this survey.

Use of the soils as woodland

About 18,500 acres in Butler County are woodland. Areas of woodland are mostly in narrow bands in small tracts along streams, or on some of the steep side slopes bordering the valleys of streams. Many of the stands would produce good sawtimber if they were properly managed. Woodland should be protected from fire and grazing and cleared of cull trees and wolf trees.

Management of woodland can be planned more effectively if the soils are grouped according to those characteristics that affect the growth of trees and the management of the stands. For this reason, the soils of Butler County that can supply enough moisture for trees have been placed in two woodland suitability groups. Only the Verdigris, Brewer, and Osage soils have been placed in these groups. All other soils in the county are considered too dry for use as woodland.

Some terms used in the descriptions of woodland suitability groups are defined in the paragraphs that follow.

Potential productivity for wood crops is expressed as *site index*, which is the average height, in feet, of the dominant and codominant species at the age of 50 years.

Seedling mortality refers to the expected degree of mortality of naturally occurring or planted seedlings as

[4] F. D. ABBOTT, State resource conservationist, and ROY M. DAVIS, area conservationist, Soil Conservation Service, helped to prepare this subsection.

influenced by soil texture, depth, drainage, floodings, height of the water table, and degree of erosion. Normal rainfall, good planting stock, and proper planting are assumed. Mortality is *slight* if the expected loss is less than 25 percent; *Moderate*, 25 to 50 percent; or *severe*, more than 50 percent.

Plant competition refers to the invasion or growth of unwanted trees, shrubs, vines, or other plants when openings are made in the canopy. Competition is *slight* if competing plants do not hinder the establishment of a desirable stand; *moderate* if they delay the establishment of a desirable stand; and *severe* if they prevent the establishment of a desirable stand unless intensive cultural measures are applied.

The ratings for equipment limitations are based on the degree that soils and relief features restrict or prohibit the use of equipment normally employed in tending a crop of trees. The limitation is *slight* if there is little or no restriction on the type of equipment that can be used or on the time of year that equipment can be used. It is *moderate* if the use of equipment is seasonally limited or if modified equipment or methods of harvesting are needed. The limitation is *severe* if special equipment is needed or if the use of such equipment is severely restricted by one or more unfavorable soil characteristics.

Erosion hazard is rated according to the risk of erosion on woodland where normal practices are used in managing and harvesting trees. It is *slight* if erosion control is not an important concern. The hazard is *moderate* if some attention must be given to check soil losses. It is *severe* if special treatment or special methods of operation are necessary.

Windthrow hazard depends on development of roots and the capacity of soil to hold trees firmly. The hazard is *slight* if windthrow is no special concern; *moderate* if roots hold the trees firmly, except when the soil is excessively wet or when the wind is strongest. The hazard is *severe* if many trees may be blown over because their roots cannot provide enough stability.

WOODLAND SUITABILITY GROUP 1

This group consists of deep, loamy, moderately well drained soils of the Brewer and Verdigris series. Permeability is moderate or slow, and runoff is slow. Flooding ranges from frequent to occasional. The site index for mixed hardwoods suited to these soils ranges from about 60 to 70. The site index for black walnut is 55 to 70. From 130 to 180 board feet annually per acre of black walnut, green ash, and hackberry and from 100 to 140 board feet annually of bur oak (fig. 20) can be expected to be produced on these soils.

***Figure 20.*—Wooded area of Verdigris silt loam in woodland suitability group 1. This soil supports excellent stands of walnut and oak.**

Seedling mortality is slight on the Brewer and Verdigris soils. It is moderate on areas of Verdigris soils that are frequently flooded. Soil conditions are favorable for good seedling survival and growth. Plant competition is moderate on the Brewer soil and on Verdigris silt loam. It is severe on Verdigris soils, frequently flooded. Some treatment is needed to remove competition of vines and weed trees.

Equipment limitations are slight. Only the frequency of flooding limits the operation of equipment. The hazards of windthrow and erosion are slight.

Black walnut, bur oak, green ash, pecan, and hackberry are the most suitable species for planting on these soils. Species to favor in existing stands are pecan; bur, red, and black oaks; walnut; ash; and hackberry.

WOODLAND SUITABILITY GROUP 2

Only Osage silty clay, which is deep, clayey, and poorly drained, is in this group. Permeability is very slow, and runoff is slow.

The native vegetation is mostly grass, but trees also grow well. The site index for mixed hardwoods that grow on this soil ranges from about 45 to 55. The expected annual yield per acre of green ash, soft maple, or American elm is 80 to 110 board feet.

Seedling mortality, caused by wetness and flooding in spring, is moderate. Loss of trees because of drought in dry summers is common. Plant competition is severe; desirable species must survive the competition of grass, weed trees, and vines.

Equipment limitations are moderate. The operation of equipment causes soil compaction and injury to roots, except during the driest months. The hazard of windthrow is severe. Stands should be opened slowly, and a tree should not be left standing alone. The hazard of erosion is slight.

The most suitable species for planting and to favor in existing stands are soft maple and green ash.

Use of the soils for windbreaks

For farmsteads and feedlots exposed to cold winds in winter and to hot winds in summer, windbreaks are

needed for protection. Trees and shrubs for windbreaks should be selected according to their suitability for the soils. Many sites considered unsuitable for use as woodland can be planted to windbreaks. On the fine-textured soils, one might consider planting trees on the contour to provide for an increase in available moisture. Nearly all of the soils in Butler County are suitable for windbreaks if the proper species of trees are selected.

The soils in Butler County have been placed in seven windbreak suitability groups, which are described in the following paragraphs. The mapping units Borrow pits (Bp) and Oil-waste land (Od) were not placed in a windbreak suitability group, because their characteristics are too variable to classify.

WINDBREAK SUITABILITY GROUP A

This group consists of deep, loamy, moderately well drained soils of the Brewer and Verdigris series. They have moderate to slow permeability and are subject to occasional and frequent overflow. Root penetration is good. The soils are suited to most trees that grow in the county. Trees and shrubs suitable for planting are—

- Evergreen trees: Austrian pine, shortleaf pine, Scotch pine, and eastern redcedar.
- Tall deciduous trees, fast growing: Siberian elm, cottonwood, silver maple, and sycamore.
- Tall deciduous trees, slow to moderate growing: Black walnut, bur oak, green ash, hackberry, honeylocust, and pin oak.
- Intermediate height deciduous trees: Osageorange, Russian mulberry, and Russian-olive.
- Shrubs: Bush-honeysuckle, lilac, multiflora rose, and American plum.

WINDBREAK SUITABILITY GROUP B

Only Osage silty clay, which is deep, clayey, and poorly drained, is in this group. This soil has very slow permeability. Runoff is slow, and the site is sometimes soggy and wet for an indefinite period. During dry periods this soil shrinks and cracks. Trees and shrubs suitable for planting are—

- Evergreen trees: Austrian pine, shortleaf pine, and eastern redcedar.
- Tall deciduous trees, fast growing: Cottonwood, silver maple, and sycamore.
- Tall deciduous trees, slow to moderate growing: Bur oak, pin oak, green ash, hackberry, and honeylocust.
- Intermediate height deciduous trees: Osageorange, Russian mulberry, and Russian-olive.
- Shrubs: Bush-honeysuckle, lilac, multiflora rose, and American plum.

WINDBREAK SUITABILITY GROUP C

This group consists of deep and moderately deep, loamy and clayey, well-drained to somewhat poorly drained soils of the Goessel, Irwin, Labette, Ladysmith, Norge, Tully, and Vanoss series (fig. 21). These soils have very slow to moderate permeability. Root penetration is good, and the moisture relationship for tree and shrub growth is fair to good. Trees and shrubs suitable for planting are—

Figure 21.—Windbreak on a Goessel silty clay of windbreak suitability group C. This windbreak protects the farmstead from winds in winter.

- Evergreen trees: Austrian pine, shortleaf pine, Scotch pine, and eastern redcedar.
- Tall deciduous trees, fast growing: Siberian elm, cottonwood, silver maple, and sycamore.
- Tall deciduous trees, slow to moderate growing: Bur oak, pin oak, green ash, hackberry, and honeylocust.
- Intermediate height deciduous trees: Osageorange, Russian mulberry, and Russian-olive.
- Shrubs: Fragrant sumac, gray dogwood, bush-honeysuckle, lilac, multiflora rose, and American plum.

WINDBREAK SUITABILITY GROUP D

This group consists of moderately deep, clayey, moderately well drained or well drained soils of the Clime and Rosehill series. These soils have very slow to moderately slow permeability. Root penetration and moisture relationship for growth are only fair. Trees and shrubs suitable for planting are—

- Evergreen trees: Austrian pine and eastern redcedar.
- Tall deciduous trees, slow to moderate growing: Bur oak, green ash, hackberry, honeylocust, and Siberian elm.
- Intermediate height deciduous trees: Osageorange, Russian mulberry, and Russian-olive.
- Shrubs: Bush-honeysuckle, lilac, multiflora rose, American plum, Fragrant sumac, and gray dogwood.

WINDBREAK SUITABILITY GROUP E

This group consists of deep and moderately deep, loamy and clayey, moderately well drained and well drained Dwight and eroded Irwin soils. These soils have very slow permeability. Root penetration is fair to poor. The soils in this group are subject to damaging drought in dry periods. Trees and shrubs suitable for planting are—

- Evergreen trees: Eastern redcedar.
- Tall deciduous trees, slow to moderate growing: Pin oak.
- Intermediate height deciduous trees: Osageorange.
- Shrubs: Fragrant sumac.

WINDBREAK SUITABILITY GROUP F

This group consists of deep and moderately deep, loamy, well-drained soils of the Benfield, Florence, La-

bette, and Olpe series. Permeability is moderately slow to very slow in these soils, and they have chert or chert gravel in their profile. Root penetration is fair to good. Moisture relationship for growth is fair to good. Trees and shrubs suitable for planting are—

Evergreen trees: Eastern redcedar, Scotch pine, and Austrian pine.
Tall deciduous trees, slow to moderate growing: Bur oak and honeylocust.
Intermediate height deciduous trees: Osageorange.
Shrubs: Fragrant sumac, gray dogwood, and American plum.

WINDBREAK SUITABILITY GROUP G

This group consists of shallow, loamy, somewhat excessively drained soils of the Sogn series. Permeability is moderate. Root penetration in this soil is slow. Moisture relationship for growth is poor. Trees and shrubs suitable for planting are—

Evergreen trees: Eastern redcedar.
Intermediate height deciduous trees: Osageorange.
Shrubs: Fragrant sumac and gray dogwood.

Use of the Soils for Wildlife[5]

Butler County has a diversity of plant and animal life. Extensive areas of native grass provide excellent habitat for prairie chicken on rangeland. Numerous valleys of streams provide habitat that is especially well suited to quail, squirrel, deer, rabbit, mink, beaver, and raccoon.

The wildlife population of any area depends upon the availability of food, cover, and water in a suitable combination. The lack of any of these items, an unfavorable balance between them, or an inadequate distribution of them can seriously limit or make impossible the use of a tract as a habitat for desired kinds of wildlife. Most wildlife habitats are created, improved, or maintained by establishing and manipulating vegetation and by providing food and water in suitable places (fig. 22).

Information about the soils is essential in carrying out these measures. It is important to consider such soil properties as permeability, drainage, fertility, and relief because any of these might be limiting factors in establishing a suitable habitat for wildlife.

A convenient way to discuss wildlife in Butler County is by soil associations. The soil associations and the soils in them are described in the section "General Soil Map." The location of each soil association is shown on the general soil map at the back of this survey. Table 4 rates the soil associations for their potential for producing elements of wildlife habitat for stated types of wildlife and fish.

Bobwhite quail are produced on all soil associations within the county. The best habitat is on the Verdigris-Brewer-Norge association. These soils support woody-type vegetation and such cultivated crops as wheat and grain sorghum.

The prairie chicken inhabits the extensive area of grassland on the Clime-Sogn, Florence-Benfield, and Labette-Sogn soil associations. This bird utilizes areas of cropland during fall and winter. The Dwight-Labette

Figure 22.—Girl Scouts planting Scotch pines to improve the habitat for wildlife.

association provides ideal areas of short grasses that are used as display or "booming grounds" by prairie chicken during spring mating season.

White-tailed deer and the mule deer live in suitable habitat in Butler County. The most favorable habitat is in the Verdigris-Brewer-Norge soil association. Deer are increasing throughout the county. White-tailed deer outnumber mule deer.

Pheasant are not numerous, but they seem to be increasing in the Goessel-Rosehill and Irwin-Ladysmith soil associations in the western part of the county.

Mink, muskrat, beaver, and raccoon live in or adjacent to water. Farm ponds, lakes, streams or marshes provide adequate habitat for these furbearers. Because the soils are subject to seepage, the Clime-Sogn association is the least desirable of any of the associations from the standpoint of pond construction.

Many song and insectivorous birds, for example, robins, meadowlarks, cardinals, flycatchers, woodpeckers, thrashers, and shrikes, occupy various habitats on all soil associations.

The mourning dove, fox squirrel, opossum, and cottontail rabbit occupy habitats primarily within the boundaries of the Verdigris-Brewer-Norge association.

Butler County is a center of watershed activity. Small reservoirs and several large reservoirs provide habitat for fish and for several species of birds and animals.

Fish in ponds, reservoirs, and streams are bass, bluegill, channel and flathead catfish, crappie, bullheads, carp, and drum.

Classes of wildlife are described as follows:

Openland Wildlife consists of birds and mammals that normally frequent croplands, pastures, meadows, lawns, and areas covered by grasses, herbs, and shrubby growth.

[5] By JACK W. WALSTROM, biologist, Soil Conservation Service.

TABLE 4.—*Potential for providing habitat elements for stated classes of wildlife and fish, by soil associations*

[Dashes in columns indicate habitat element not applicable to class of wildlife or to fish]

Soil association	Class of wildlife and fish	Habitat elements			
		Woody cover	Herbaceous cover	Aquatic habitat	Food
1. Goessel-Rosehill.	Upland	Good	Excellent	Good	Good.
	Woodland	Good	Good	Good	Good.
	Wetland			Good	Good.
	Fish			Good	Good.
2. Irwin-Ladysmith.	Upland	Good	Excellent	Good	Good.
	Woodland	Good	Good	Good	Good.
	Wetland	Good	Good	Good	Good.
	Fish			Good	Good.
3. Verdigris-Brewer-Norge.	Upland	Excellent	Excellent	Excellent	Excellent.
	Woodland	Excellent	Excellent	Excellent	Excellent.
	Wetland	Excellent	Excellent	Excellent	Excellent.
	Fish			Excellent	Excellent.
4. Dwight-Labette.	Upland	Poor	Fair	Good	Good.
	Woodland	Poor	Fair	Good	Good.
	Wetland			Good	Good.
	Fish			Good	Good.
5. Labette-Sogn.	Upland	Good	Excellent	Good	Fair.
	Woodland	Fair	Good	Good	Fair.
	Wetland			Fair	Poor.
	Fish			Fair	Fair.
6. Florence-Benfield.	Upland	Good	Excellent	Good	Good.
	Woodland	Good	Good	Good	Good.
	Wetland	Fair	Fair	Good	Good.
	Fish			Good	Good.
7. Clime-Sogn.	Upland	Good	Excellent	Fair	Fair.
	Woodland	Fair	Good	Fair	Fair.
	Wetland			Poor	Poor.
	Fish			Poor	Poor.
8. Norge-Ladysmith.	Upland	Excellent	Excellent	Excellent	Excellent.
	Woodland	Good	Excellent	Excellent	Excellent.
	Wetland		Good	Good	Good.
	Fish			Good	Good.

Examples of this kind of wildlife are quail, prairie chicken, pheasant, meadowlarks, field sparrows, red-winged blackbirds, cottontail rabbit, red fox, ground squirrels, and marmots.

Woodland Wildlife consists of birds and mammals that normally frequent wooded areas composed of hardwood trees and shrubs, coniferous trees and shrubs, or mixtures of these types of plants. Examples of this kind of wildlife are thrushes, vireos, fox squirrels, red fox, whitetailed and mule deer, and raccoon.

Wetland Wildlife consists of birds and mammals that normally frequent such wet areas as ponds, streams, ditches, marshes, and swamps. Examples of this kind of wildlife are wood ducks, mallards, pintails, herons, shore birds, mink, muskrats, and beavers.

Technical assistance in planning and developing fish and wildlife areas can be obtained from the Soil Conservation Service office at El Dorado. Other agencies offering assistance include the Forestry, Fish, and Game Commission, Bureau of Sport Fisheries and Wildlife, and the County Extension Service.

Soil Interpretations for Recreational Uses [6]

Butler County is easily accessible to a large number of people seeking recreation. Water-based recreational activities are increasing as multipurpose watershed sites are developed in the county.

The limitations that affect the suitability of soils as recreational sites are rated in table 5. The degree of limitation is rated *slight*, *moderate*, and *severe*, which have the following meanings:

Slight means that the soil has few or no limitations for the stated use or that limitations can be easily overcome.

Moderate means that some planning and engineering practices are needed to overcome the limitations.

Severe means that the soil is poorly suited to the stated use and that intensive engineering practices and a large investment are needed to overcome the soil limitations.

[6] By JACK W. WALSTROM, biologist, Soil Conservation Service.

TABLE 5.—*Degree and kind of soil limitations that affect stated recreational uses*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil, which may have different properties and limitations. The reader should follow carefully the instructions for referring to another series in this column]

Soil series and map symbols	Camp areas	Picnic areas	Intensive play areas	Paths and trails
*Benfield: Be. For limitations of the Labette part of this unit, see the Labette series.	Moderate: 2 to 12 percent slopes; cherty silty clay loam surface layer.	Moderate: 2 to 12 percent slopes; cherty silty clay loam surface layer.	Moderate if slopes are 2 to 6 percent; severe if slopes are more than 6 percent.	Moderate: cherty silty clay loam surface layer.
Borrow pits: Bp. Properties too variable for valid interpretations.				
Brewer: Br	Severe: subject to flooding.	Moderate: subject to flooding.	Moderate: subject to flooding.	Moderate: silty clay loam surface layer.
*Clime: Cs. For limitations of the Sogn part of this unit, see the Sogn series.	Severe: silty clay surface layer; 3 to 15 percent slopes.	Severe: silty clay surface layer.	Severe: silty clay surface layer; 3 to 15 percent slopes.	Severe: silty clay surface layer.
Dwight.				
Dt	Severe: very slow permeability.	Moderate: moderately well drained.	Severe: very slow permeability.	Slight.
Dw	Severe: very slow permeability.	Severe: silty clay loam and silty clay surface layer.	Severe: very slow permeability.	Moderate to severe: silty clay loam and silty clay surface layer
Florence: Fc	Moderate: 5 to 10 percent slopes; cherty silt loam surface layer.	Moderate: 5 to 10 percent slopes; cherty silt loam surface layer.	Severe: 5 to 10 percent slopes; cherty silt loam surface layer.	Moderate: cherty silt loam surface layer.
Goessel: Go, Gs	Severe: silty clay surface layer; very slow permeability.	Severe: silty clay surface layer.	Severe: silty clay surface layer; very slow permeability.	Severe: silty clay surface layer.
Irwin: Ic, Id, Ie, If	Severe: very slow permeability.	Moderate: silty clay loam surface layer.	Severe: very slow permeability.	Moderate: silty clay loam surface layer.
*Labette: La, Lb, Lc, Ld, Le. For limitations of the Dwight part of unit Ld and of the Sogn part of unit Le, see the Dwight and Sogn series, respectively.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer; 1 to 5 percent slopes; slow permeability.	Moderate: silty clay loam surface layer.
Ladysmith: Ls	Severe: very slow permeability.	Moderate: silty clay loam surface layer.	Severe: very slow permeability.	Moderate: silty clay loam surface layer.
Norge:				
No, Nr, Ns	Slight	Slight	Slight	Slight.
Nt	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate. silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Oil-waste land: Od	Severe: severe hazard of erosion.	Severe: severe hazard of erosion.	Severe· severe hazard of erosion.	Moderate: severe hazard of erosion.
*Olpe· On. For limitations of the Norge part of this unit, see the Norge series.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: 2 to 7 percent slopes; silty clay loam surface layer.	Moderate: silty clay loam surface layer.

TABLE 5.—*Degree and kind of soil limitations that affect stated recreational uses*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Intensive play areas	Paths and trails
Osage: Os	Severe: poorly drained; wetness; very slow permeability; silty clay surface layer.	Severe: poorly drained; wetness; silty clay surface layer.	Severe: poorly drained; wetness; very slow permeability; silty clay surface layer.	Severe: poorly drained; wetness; silty clay surface layer.
Rosehill: Ro	Severe: silty clay surface layer.	Severe: silty clay surface layer.	Severe: silty clay surface layer; very slow permeability.	Severe: silty clay surface layer.
Sogn: So	Severe: rock outcrop	Severe: rock outcrop	Severe: shallow depth; rock outcrop.	Severe: rock outcrop.
Tully: Ts, Tt, Tu	Moderate: slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Vanoss: Va, Vb	Slight	Slight	Slight	Slight.
Verdigris:				
Vd	Severe: subject to flooding.	Moderate: subject to flooding.	Moderate: subject to frequent flooding.	Slight.
Ve	Severe: subject to frequent flooding.	Severe: subject to frequent flooding.	Severe: subject to frequent flooding.	Moderate: subject to frequent flooding.

These ratings provide general information on soil suitability, but a specific site of construction should be given a detailed investigation before construction is started.

The paragraphs that follow describe the method of rating the soils for each use. Table 5 shows the degree and main limitation to use.

Camp areas.—These areas are used intensively for tents, small camp trailers, and their related activities. They should be suitable for heavy foot or vehicular traffic. These areas are used frequently during the camping season. The suitability of the soils for vegetation should be considered separately in selecting an area for a camp site.

Picnic areas.—Ratings of the soils for this use are based on such soil features as texture, drainage, and slope. Such factors such as lakes, trees, or beauty of the landscape may add to the desirability of the site.

Intensive play areas.—Such activities as baseball, football, and badminton, as well as sites for playgrounds, are considered in this category. Generally required are a nearly level soil that has good drainage and a surface free of rocks (fig. 23). It is assumed that a good cover of plants can be established and maintained where needed.

Paths and trails.—Within this category are trails for cross-country hiking, bridle paths for horseback riding, and other sites for nonintensive use. Generally, the soils should not need much grading or sloping. The ratings are based on soil features only and do not include other features, such as beauty of the landscape, that are important when selecting a site for trails or paths.

Engineering Uses of the Soils [7]

This subsection is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to water table, depth to bedrock, and soil slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this subsection can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 6, 7, and 8, which show, respectively, several esti-

[7] By GERALD D. NORRIS, civil engineer, Soil Conservation Service.

Figure 23.—Polo field on an area of Verdigris silt loam.

mated soil properties significant to engineering; interpretations for various engineering uses; and results of engineering laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 6 and 7, and it also can be used to make other useful maps.

This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 5 feet. Also, inspection of sites, especially the small ones, is needed bcause many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists that is not known to all engineers. The "Glossary" defines many of these terms commonly used in soil science.

Engineering soil classification systems

Agricultural scientists of the U.S. Department of Agriculture (USDA) classify soils according to texture, color, and structure. This system is useful only as the initial step in making engineering soil classifications. The engineering properties of a soil must be determined or estimated after the initial classifications have been made. Two systems are used by engineers for classifying soils. These are the systems used by the American Association of State Highway Officials (AASHO) (*1*) and the Unified System (*13*). These systems are explained briefly in the following paragraphs. The explanations are taken largely from the PCA Soil Primer (*7*).

The AASHO system is used to classify soils according to those properties that affect use for highway construction and maintenance. In this system all the soils are classified in seven groups. The soils most suitable for road subgrade are classed as A–1, and the soils least suitable are classed as A–7. Within rather broad limits, soils are classified numerically between these two extremes according to their load-carrying ability. Three of the seven basic groups may be further divided into subgroups to designate variations within a group. Within each group, the relative engineering value of the soil material is indicated by a group index number, which is shown in parentheses following the group classification. Group index numbers range from 0 for the best material to 20 for the poorest. Increasing values of group index numbers denote decreasing load-carrying capacity.

TABLE 6.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil, which may
The sign > means more than;

Soil series and map symbols	Depth to bedrock	Depth from surface of typical profile	Classification		
			Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
*Benfield:[1] Be	2–3½	0–9	Cherty silty clay loam	CL	A–7
For properties of the Labette part of this unit, see the Labette series.		9–23	Cherty silty clay	CH	A–7
		23–35	Silty clay	CH or CL	A–7
		35	Shale.		
Borrow pits: Bp. Properties too variable for valid estimates.					
Brewer: Br	>5	0–21	Silty clay loam	CL	A–7
		21–66	Silty clay	CH	A–7
*Clime. Cs	2–3½	0–33	Silty clay	CL or CH	A–7
For properties of the Sogn part of this unit, see the Sogn series.		33	Shale.		
Dwight: Dt, Dw	2–3½	0–5	Silt loam	ML or ML–CL	A–4 or A–6
		5–36	Silty clay	CH	A–7
		36	Limestone.		
Florence:[2] Fc	3½–5	0–14	Cherty silt loam	GM, GC, ML, or CL	A–2 or A–6
		14–45	Cherty clay	GC or CH	A–2 or A–7
		45	Cherty limestone.		
Goessel: Go, Gs	>5	0–18	Silty clay	CH or CL	A–7
		18–44	Silty clay	CH	A–7
		44–68	Silty clay	CH or CL	A–7
Irwin: Ic, Id, Ie, If	>5	0–11	Silty clay loam	CL	A–6
		11–66	Silty clay	CH	A–7
*Labette: La, Lb, Lc, Ld, Le	1½–3½	0–13	Silty clay loam	CL or ML–CL	A–6 or A–7
For properties of the Dwight part of unit Ld and of the Sogn part of unit Le, see the Dwight and Sogn series, respectively.		13–38	Silty clay	CH	A–7
		38	Limestone.		
Ladysmith: Ls	>5	0–8	Silty clay loam	CL	A–6
		8–66	Silty clay	CH or CL	A–7
Norge: No, Nr, Ns, Nt	>5	0–9	Silt loam	ML	A–4
		9–72	Silty clay loam	CL	A–6
Oil-waste land: Od. Properties too variable for valid estimates.					
*Olpe: On	>5	0–14	Silty clay loam	CL	A–6
For properties of the Norge part of this unit, see the Norge series.		14–30	Gravelly clay	GC	A–2
		30–42	Clay	CH	A–7
		42–55	Gravelly clay	GC	A–2
Osage: Os	>5	0–66	Silty clay	CH	A–7
Rosehill: Ro	2–3½	0–36	Silty clay	CH	A–7
		36	Shale.		
Sogn:[3] So	½–1½	0–7	Silty clay loam	CL	A–6 or A–7
		7	Limestone.		
Tully: Ts, Tt, Tu	>5	0–16	Silty clay loam	CL	A–6
		16–64	Silty clay	CH	A–7
Vanoss: Va, Vb	>5	0–12	Silt loam	ML–CL or CL	A–4 or A–6
		12–57	Silty clay loam	CL	A–6

See footnote at end of table.

significant to engineering

have different properties. The reader should follow *carefully* the instructions for referring to another series in the first column of this table. the sign < means less *than*]

Percentage passing sieve— No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	Permeability	Available water capacity	Reaction	Shrink-swell potential
				Inches per hour	*Inches per inch of soil*	*pH*	
90–95	90–95	90–95	90–95	0.20–0.63	0.17–0.19	6.1–7.8	Moderate.
60–70	60–70	60–70	60–70	0.06–0.20	0.17–0.19	6.1–7.8	High.
85–100	85–95	85–95	70–90	0.06–0.20	0.17–0.19	6.1–8.4	Moderate to high.
100	100	90–100	90–100	0.20–0.63	0.17–0.19	6.1–7.3	Moderate.
100	100	95–100	95–100	0.06–0.20	0.17–0.19	6.1–7.3	High.
100	100	95–100	85–95	0.20–0.63	0.17–0.19	7.4–8.4	Moderate.
100	100	95–100	95–100	0.20–0.63	0.16–0.18	5.6–6.5	Low.
100	100	95–100	95–100	<0.06	0.17–0.19	6.6–8.4	High.
20–80	16–76	16–70	16–66	0.20–0.63	0.06–0.08	6.1–7.3	Low to moderate.
20–75	16–70	16–70	16–66	0.20–0.63	0.04–0.06	6.1–7.8	Low to moderate.
100	100	95–100	95–100	<0.06	0.17–0.19	6.1–7.3	High.
100	100	95–100	95–100	<0.06	0.17–0.19	6.6–8.4	High.
100	100	95–100	85–95	<0.06	0.17–0.19	6.6–8.4	High.
100	95–100	90–100	90–100	0.20–0.63	0.17–0.19	5.6–7.3	Moderate.
95–100	95–100	90–100	90–100	<0.06	0.17–0.19	6.6–8.4	High.
100	100	95–100	95–100	0.20–0.63	0.17–0.19	5.6–6.5	Moderate.
100	100	95–100	95–100	0.06–0.20	0.17–0.19	5.6–8.4	High.
100	100	95–100	95–100	0.20–0.63	0.17–0.19	5.6–7.3	Moderate.
100	100	95–100	95–100	<0.06	0.17–0.19	6.1–7.8	High.
100	100	95–100	90–100	0.63–2.00	0.17–0.19	5.6–6.5	Low.
100	100	95–100	90–100	0.20–0.63	0.17–0.19	6.1–7.3	Moderate.
80–90	80–90	80–90	80–90	0.20–0.63	0.17–0.19	5.6–6.5	Moderate.
20–30	20–30	15–25	15–25	<0.06	0.04–0.05	5.6–7.3	Low.
90–100	90–100	90–100	90–100	<0.06	0.17–0.19	5.6–7.3	High.
20–30	20–30	15–25	15–25	<0.06	0.04–0.05	6.1–7.8	Low.
100	100	95–100	95–100	<0.06	0.17–0.19	6.1–7.8	High.
95–100	95–100	90–100	90–100	<0.06	0.17–0.19	6.1–8.4	High.
85–95	85–95	85–95	85–95	0.63–2.00	0.17–0.19	6.1–8.4	Moderate.
95–100	95–100	90–100	80–95	0.20–0.63	0.17–0.19	5.6–7.3	Moderate.
95–100	95–100	90–100	80–95	0.06–0.20	0.17–0.19	6.1–7.8	High.
100	100	100	90–100	0.63–2.00	0.17–0.19	5.6–6.5	Low.
100	100	100	90–100	0.63–2.00	0.17–0.19	5.6–7.3	Moderate.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to bedrock	Depth from surface of typical profile	Classification: Dominant USDA texture	Classification: Unified	Classification: AASHO
	Feet	*Inches*			
Verdigris: Vd, Ve	>5	0–8 8–57	Silt loam Silty clay loam	CL CL	A–6 A–6

[1] For the Benfield soil, the estimate of fragments larger than 3 inches in diameter is 0 to 5 percent in all layers. For the Labette soil in unit Be, the estimate of fragments larger than 3 inches in diameter is 5 to 10 percent in the 0- to 13-inch layer and 10 to 30 percent in the 13- to 38-inch layer.

TABLE 7.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil, which may series in the

Soil series and map symbols	Suitability as source of—: Topsoil	Suitability as source of—: Sand and gravel	Suitability as source of—: Road subgrade [1]	Suitability as source of—: Road fill [1]	Soil features affecting—: Highway location [1]	Soil features affecting—: Dikes and levees
*Benfield: Be. For interpretations of the Labette part of this unit, see the Labette series.	Fair	Unsuitable	Poor: high shrink-swell potential.	Fair: low stability.	High plasticity; bedrock at depth of 2 to 3½ feet; irregular relief.	High shrink-swell potential; low stability.
Borrow pits: Bp. Properties too variable for valid interpretations.						
Brewer: Br	Good in surface layer.	Unsuitable	Poor: high shrink-swell potential.	Fair: moderate to low stability.	High shrink-swell potential; subject to flooding; slow internal drainage; nearly level.	Moderate to low stability.
*Clime: Cs. For interpretations of the Sogn part of this unit, see the Sogn series.	Fair	Unsuitable	Fair: moderate stability; low shear strength; plastic.	Good	Shale at depth of 2 to 3½ feet; possible seep areas; irregular relief.	Not applicable

See footnotes at end of table.

significant to engineering—Continued

Percentage passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0 42 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH*	
100	100	95–100	90–100	0. 63–2. 00	0. 17–0. 19	5. 6–6. 5	Moderate to low.
100	100	95–100	90–100	0. 63–2. 00	0. 17–0. 19	5. 6–6. 5	Moderate.

[2] The estimate of fragments larger than 3 inches in diameter is 0 to 75 percent in the 0- to 14-inch layer and in the 14- to 45-inch layer.
[3] The estimate of fragments larger than 3 inches in diameter is 0 to 20 percent.

engineering properties

have different properties and interpretations. For this reason the reader should follow carefully the instructions for referring to another first column]

Soil features affecting—Continued						Soil limitations for sewage disposal	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Foundations for low buildings	Septic tank filter field	Sewage lagoons
Reservoir area	Embankment [2]						
Slow permeability, bedrock at depth of 2 to 3½ feet.	Low stability; high shrink-swell potential.	Not applicable.	Not applicable.	Not applicable	High shrink-swell potential.	Severe: slow permeability; bedrock at depth of 2 to 3½ feet.	Severe: bedrock at depth of 2 to 3½ feet
Slow permeability; nearly level.	Moderate to low stability, high shrink-swell potential.	Moderately well drained; subject to flooding.	Not applicable.	Not applicable.	High shrink-swell potential.	Severe: slow permeability; subject to flooding.	Severe where subject to flooding; slight where protected from flooding.
Moderately slow permeability, shale at depth of 2 to 3½ feet.	Borrow material limited; moderate to high shrink-swell potential.	Not applicable.	Not applicable.	Not applicable	No adverse features where foundation rests on shale.	Severe: shale at depth of 2 to 3½ feet; possible seep areas.	Severe: moderately slow permeability; shale at depth of 2 to 3½ feet; moderate to high shrink-swell potential.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand and gravel	Road subgrade [1]	Road fill [1]	Highway location [1]	Dikes and levees
Dwight: Dt, Dw	Poor	Unsuitable	Poor: high shrink-swell potential; high plasticity; low shear strength.	Poor: low stability; dispersed subsoil; poor compaction characteristics.	High plasticity; very slow internal drainage; dispersed subsoil; nearly level and gently sloping.	Cracks when dry
Florence: Fc	Poor	Fair for road gravel.	Good to poor, depending on size of chert fragments.	Good	Irregular relief; 50 to 85 percent fragments of angular chert.	Borrow material limited and cherty.
Goessel: Go, Gs	Poor	Unsuitable	Poor: high shrink-swell potential; low shear strength; high plasticity.	Fair: low stability; high shrink-swell potential; low shear strength.	Slow surface drainage; high plasticity.	Low shear strength; cracks when dry; low stability.
Irwin: Ic, Id, Ie, If.	Fair in surface layer; poor in subsoil.	Unsuitable	Poor: high shrink-swell potential; low shear strength; plastic.	Fair: low stability; high shrink-swell potential; low shear strength.	High plasticity; very slow permeability; nearly level to sloping.	Low stability; plastic.
*Labette: La, Lb, Lc, Ld, Le For interpretations of the Dwight part of unit Ld and of the Sogn part of unit Le, see the Dwight and Sogn series, respectively.	Good in upper 12-inch layer.	Unsuitable	Poor: moderate to high shrink-swell potential; low shear strength.	Fair: low stability. Moderate to high shrink-swell potential.	Nearly level to sloping, moderate to high shrink-swell potential; bedrock at depth of 1½ to 3½ feet.	Low stability; cracks when dry.
Ladysmith: Ls	Fair in surface layer; poor in subsoil.	Unsuitable	Poor: high shrink-swell potential; plastic; low shear strength.	Fair: low stability; high shrink-swell potential; low shear strength.	High plasticity; very slow permeability; nearly level and gently sloping.	Low stability; cracks when dry.
Norge: No, Nr, Ns, Nt.	Fair	Unsuitable	Fair to poor: moderate shrink-swell potential.	Good	Moderate plasticity; nearly level to sloping.	Slight or moderate hazard of erosion.

See footnotes at end of table.

engineering properties—Continued

Soil features affecting—Continued							Soil limitations for sewage disposal	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Foundations for low buildings	Septic tank filter field	Sewage lagoons	
Reservoir area	Embankment [2]							
Very slow permeability; bedrock at depth of 2 to 3½ feet.	Low shear strength; cracks when dry, dispersed subsoil.	Very slow permeability.	Thin surface layer.	Thin surface layer, grass difficult to establish.	High shrink-swell potential, low shear strength.	Severe: very slow permeability.	Severe: low stability; bedrock at depth of 2 to 3½ feet; plastic; cracks when dry.
Bedrock at depth of 3½ to 5 feet.	Borrow material limited and cherty; possible seep areas; good stability.	Not applicable.	Not applicable	Not applicable.	No adverse features	Severe: moderately slow permeability; bedrock at depth of 3½ to 5 feet; cherty.	Severe: bedrock at depth of 3½ to 5 feet, cherty.
Very slow permeability.	Low shear strength; cracks when dry; high plasticity.	Slow surface drainage; very slow permeability.	Cracks when dry; very slow permeability.	Crusty surface layer; grass difficult to establish.	High shrink-swell potential.	Severe: very slow permeability.	Slight.
Very slow permeability.	Low stability; plastic; cracks when dry.	Not applicable.	Cracks when dry, very slow permeability.	Crusty surface layer, grass difficult to establish.	High shrink-swell potential; low shear strength; plastic.	Severe: very slow permeability.	Slight where slopes are less than 2 percent; moderate where slopes are 2 to 5 percent.
Bedrock at depth of 1½ to 3½ feet; possible seep areas; slow permeability.	Low stability; moderate to high shrink-swell potential.	Not applicable.	Bedrock at depth of 1½ to 3½ feet.	Bedrock at depth of 1½ to 3½ feet.	Moderate to high shrink-swell potential; good if on limestone.	Severe: slow permeability; bedrock at depth of 1½ to 3½ feet.	Severe: bedrock at depth of 1½ to 3½ feet.
Nearly level and gently sloping; very slow permeability.	Low stability; high plasticity; cracks when dry.	Moderately well drained to somewhat poorly drained; very slow permeability	Cracks when dry; clayey subsoil.	Surface crusts, grass difficult to establish.	High shrink-swell potential; low shear strength; plastic.	Severe: very slow permeability.	Slight.
Moderately slow permeability.	Moderate plasticity; slight or moderate hazard of erosion.	Not applicable.	No adverse features.	Subsoil fair for establishing vegetation.	Moderate plasticity.	Moderate: moderately slow permeability.	Slight where slopes are less than 2 percent; moderate where slopes are 2 to 7 percent.

TABLE 7.—*Interpretations of*

Soil series and map symbols	Suitability as source of—				Soil features affecting—	
	Topsoil	Sand and gravel	Road subgrade [1]	Road fill [1]	Highway location [1]	Dikes and levees
Oil-waste land: Od. Properties too variable for valid interpretations.						
*Olpe: On. For interpretations of the Norge part of this unit, see the Norge series.	Poor	Suitable only for dirt road gravel.	Good	Good	Gravelly soils; high stability; irregular relief.	Borrow material limited and gravelly.
Osage: Os	Poor	Unsuitable	Poor: high shrink-swell potential; high plasticity; low shear strength.	Fair: low stability; high shrink-swell potential; low shear strength.	High plasticity; very slow permeability; poor surface drainage; nearly level; subject to ponding.	Low stability; cracks when dry.
Rosehill: Ro	Poor	Unsuitable	Poor: high shrink-swell potential; low shear strength; high plasticity.	Fair: low stability: high shrink-swell potential; low shear strength.	High plasticity; very slow permeability; shale at depth of 2 to 3½ feet; gently sloping.	Low stability; high plasticity.
Sogn: So	Poor	Unsuitable	Poor: moderate shrink-swell potential.	Good: limited amount.	Moderate plasticity; nearly level to sloping; limestone at depth of ½ foot to 1½ feet.	Limestone at depth of ½ foot to 1½ feet.
Tully: Ts, Tt, Tu	Fair	Unsuitable	Poor: high shrink-swell potential; plastic; low shear strength.	Fair: low stability; moderate to high shrink-swell potential; plastic.	High plasticity; slow permeability; gently sloping and sloping; low stability.	Low stability
Vanoss: Va, Vb	Good	Unsuitable	Fair to poor	Good	Moderate plasticity; nearly level and gently sloping.	Moderate stability; moderate compaction characteristics.
Verdigris: Vd, Ve	Good	Unsuitable	Poor: moderate stability.	Good	Subject to occasional or frequent flooding; nearly level.	Moderate stability.

[1] NORMAN CLARK, engineer of soils, and HERBERT E. WORLEY, soils research engineer, Kansas State Highway Commission, assisted in preparing these columns.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for sewage disposal	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Foundations for low buildings	Septic tank filter field	Sewage lagoons
Reservoir area	Embankment [2]						
Slow to very slow permeability; gravelly.	High stability if mixed.	Not applicable.	Not applicable.	Not applicable.	Gravelly subsoil.	Severe: slow to very slow permeability.	Severe: gravelly subsoil.
Very slow permeability.	Low stability; cracks when dry; high plasticity.	Poorly drained; subject to ponding.	Not applicable.	Not applicable.	High shrink-swell potential; subject to ponding.	Severe: very slow permeability.	Severe where flooded; slight where protected from flooding.
1 to 3 percent slopes; very slow permeability.	Low stability; high plasticity.	Not applicable.	Clayey texture, very slow permeability; shale at depth of 2 to 3½ feet.	Clayey texture; grass difficult to establish, deep cuts likely to expose shaley areas.	High shrink-swell potential; shale at depth of 2 to 3½ feet.	Severe: very slow permeability; shale at depth of 2 to 3½ feet.	Severe: bedrock at depth of 2 to 3½ feet.
Limestone at depth of ½ foot to 1½ feet.	Very limited borrow material; moderate stability.	Not applicable.	Not applicable.	Not applicable.	Limestone at depth of ½ foot to 1½ feet.	Severe: limestone at depth of ½ foot to 1½ feet.	Severe: limestone at depth of ½ foot to 1½ feet.
No adverse features.	Low stability; high shrink-swell potential.	Not applicable.	Clayey subsoil; reserves runoff from other areas.	Clayey subsoil; medium to rapid runoff.	Moderate to high shrink-swell potential.	Severe: slow permeability.	Moderate: 2 to 7 percent slopes.
Moderate permeability.	Moderate stability and compaction characteristics.	Not applicable.	Moderate hazard of erosion in unit Vb.	Moderate hazard of erosion in unit Vb.	Low to moderate shrink-swell potential.	Moderate: moderate permeability.	Slight to moderate: moderate permeability.
Nearly level...	Moderate stability; moderate to low shrink-swell potential.	Not applicable	Not applicable.	Subject to occasional or frequent flooding.	Subject to occasional or frequent flooding.	Severe: subject to occasional or frequent flooding.	Moderate where protected from flooding; severe where not protected from flooding.

[2] Embankments more than about 25 feet high not considered.

TABLE 8.—*Engineering*

[Tests were performed by the State Highway Commission of Kansas in accordance with standard

Soil name and location	Parent material	SCS sample No.	Depth from surface	Moisture-density [1]		Mechanical analysis [2]	
				Maximum dry density	Optimum moisture	Percentage passing sieve	
						No. 10 (2.0 mm.)	No. 40 (0.42 mm.)
		S59-Kansas	*Inches*	*Lb. per cu. ft.*	*Percent*		
Dwight silt loam: 125 yards south and 50 yards east of NW. corner of sec. 20, T. 26 S., R. 6 E. (Modal)	Clayey sediment.	8-3-1	0-5	94	20	----------	100
		8-3-2	5-14	92	23	----------	----------
		8-3-5	28-35	94	23	100	99
Goessel silty clay: 375 yards east and 50 yards south of NW. corner of sec. 32, T. 24 S., R. 3 E. (Modal)	Clayey sediment.	8-1-1	0-6	96	22	100	99
		8-1-3	15-24	96	21	100	99
		8-1-8	55-64	104	18	100	99
Irwin silty clay loam: 1,710 yards west and 225 yards south of NE. corner of sec. 19, T. 23 S., R. 5 E. (Modal)	Clayey sediment.	8-6-1	0-6	102	16	----------	100
		8-6-3	8-19	96	20	----------	----------
		8-6-6	35-41	98	21	100	99
		8-6-8	51-61	94	21	----------	----------
Ladysmith silty clay loam: 400 yards west and 100 yards north of SE. corner of sec. 28, T. 23 S., R. 3 E. (Modal)	Clayey sediment.	8-4-1	0-6	102	18	100	99
		8-4-3	8-21	92	25	----------	100
		8-4-6	38-47	100	21	100	98
		8-4-8	57-76	95	25	100	97

[1] Based on AASHO Designation T 99-57 (*1*) with the following variations: (1) all material is ovendried at 230° F., (2) all material is crushed in laboratory crusher after drying, and (3) no time is allowed for dispersion of moisture after mixing with soil material

[2] Mechanical analyses according to AASHO Designation T 88-57 (*1*), with the following variations: (1) all material is ovendried at 230° F and crushed in laboratory crusher, (2) sample is not soaked prior to dispersion; (3) sodium silicate is used as dispersing agent; and (4) dispersing time, in minutes, is established by using half the plasticity index value, the maximum time of which is 15 minutes and the minimum is 1 minute. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer

In the AASHO system the soil material may be divided into the following two major groups: (1) Granular material in which 35 percent or less passes a 200-mesh sieve, and (2) silt-clay material in which more than 35 percent passes a 200-mesh sieve. The silty part of the silt-clay material has a plasticity index of 10 or less, and the clayey material has a plasticity index greater than 10.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML-CL.

After an engineer has been trained and has had experience, he can make approximate classifications of soils, based on visual field inspection and observation of a few hand tests. Exact classification, however, must be based on data obtained from complete laboratory analyses. Field classifications are useful in determining when and upon which soils laboratory analyses should be made.

Engineering properties of soils

In table 6 some of the depths from the surface differ slightly from the descriptions of the typical profiles given in the section "Descriptions of the Soils." The purpose of the depths from the surface given in table 6 is to show the horizons that have features significant to engineering. The underlying, or parent, material generally is not named. The soils are underlain, however, by various formations of limestone and shale and by alluvium.

Because the soils in Butler County have various underlying formations of limestone and shale, onsite investigations are necessary for various engineering works. The Labette-Sogn soil association in the central part of the county, for example, contains many "sinkholes," which are evidence of the porous substratum of the Fort Riley limestone member. Construction of reservoirs in this area is hazardous because of seepage. In the eastern part of the county, soils formed in material derived from the Kinney limestone member have similar characteristics. The Florence limestone member, although very cherty, seldom has a seepage problem.

Sand deposits are nearly absent in the county, although a few very small deposits are located in the western part

test data

procedures of the American Association of State Highway Officials (AASHO) (*1*)]

Mechanical analysis [1]—Continued						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued		Percentage smaller than—						AASHO	Unified
No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	*Percent*			
99	98	85	54	23	14	37	12	A-6(9)	ML-CL
100	99	92	69	40	33	55	31	A-7-6(19)	CH
99	98	95	76	48	34	59	35	A-7-6(20)	CH
98	95	89	66	38	25	47	26	A-7-6(16)	CL
98	97	92	68	42	30	55	33	A-7-6(19)	CH
98	93	89	54	([2])	([2])	42	22	A-7-6(13)	CL
99	98	90	58	24	13	33	12	A-6(9)	CL
-----------	100	92	72	42	30	52	29	A-7-6(18)	CH
98	97	94	70	34	21	46	25	A-7-6(15)	CL
100	98	92	76	44	28	57	32	A-7-6(19)	CH
98	96	87	60	25	15	34	14	A-6(10)	CL
99	99	94	76	48	33	56	33	A-7-6(19)	CH
97	93	87	68	38	26	47	27	A-7-6(16)	CL
95	91	82	66	37	24	53	26	A-7-6(17)	MH-CH

method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[2] The percentage of material smaller than 0.005 and 0.002 millimeter could not be determined by hydrometer analysis, because of flocculation caused by the presence of gypsum. The percentage of material smaller than 0.02 millimeters may be slightly influenced because of flocculation.

of the county. These deposits are in the Whitewater area, primarily in the vicinity of Norge soils. Chert gravels are on benches that parallel streams between Leon and Douglass in the southern part of the county. These gravels are, for the most part, in the Olpe-Norge complex and are used for road base material. Most of the soils on uplands in the county are either too clayey or too shallow to rock for desirable septic tank development. Such soils as the Irwin, Ladysmith, Goessel, and Dwight have very slow permeability. Soils in Butler County do not have a seasonal high water table. The Labette, Sogn, and Rosehill soils have additional hazards of being underlain by limestone or shale at depth of less than 40 inches. Additional information about the underlying materials is given under "Parent Material" in the section "Formation and Classification of the Soils."

Soil texture is described in table 6 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. *Loam*, for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added; for example, *gravelly loamy sand*. *Sand*, *silt*, *clay*, and some other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 6 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Salinity generally is not a problem in this county. There are some areas of slickspots in the various mapping units, as shown by a symbol on the map; but these areas are small in size and number. The mapping unit Oil-waste land consists of soils that have been severely affected by

oil, salt water, or other wastes; and it generally is affected by salts.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content; that is, the extent to which the soil shrinks as it dries out or swells as it becomes wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Engineering interpretations of soils

Table 7 provides information useful to engineers and others who plan to use soil material in construction of highways, farm facilities, buildings, and sewage disposal systems. The table lists specific features of the soils that affect the selection, design, or application of engineering works. Generally, only detrimental or undesirable features are listed, but some desirable features are also listed.

In table 7 soil suitability is rated by use of the terms *good*, *fair*, *poor*, or *unsuitable;* and these apply to the whole soil profile, unless a specific soil horizon is named. The ratings and interpretations in this table are based on estimated soil properties reflected by available test data, including those in table 8, and on field experiences. Following are explanations of some of the terms used in table 7.

Topsoil is fertile soil or soil material, ordinarily rich in organic matter, that is used to topdress lawns, gardens, roadbanks, and the like. The soils are also rated as a source of sand and gravel. In this county only very small areas are sources of clean sand and gravel.

The ratings for road subgrade and road fill pertain to the qualities of the disturbed soil material borrowed for those uses.

In rating soil suitability for highway location, soil features that affect choice of the geographic location of highways are considered. The entire soil profile is evaluated, based on undisturbed soil without artificial drainage, but from which the organic surface layer has been removed.

Suitability of the soils for dikes and levees is based on the expected behavior of soil material borrowed for construction of low embankments that involve no more than a slight hazard.

Soil features given for farm pond reservoir areas are those that affect the rate of water seepage through undisturbed soils in impoundment areas.

For farm pond embankments, those features and qualities that affect suitability of disturbed soils for constructing earth fills are considered. Both the subsoil and the substratum are evaluated where they have adequate thickness for use as borrow material.

Agricultural drainage depends on those soil properties that affect the installation and performance of surface and subsurface drainage practices.

For terraces and diversions, detrimental or undesirable features that affect stability or hinder layout and construction are given; also considered is sedimentation in channels and difficulty of establishment and maintenance of a cover of plants on diversions.

Grassed waterways are affected by factors that hinder layout and construction and that affect the establishment, growth, and maintenance of a plant cover.

The features affecting foundations for low buildings are those pertaining to an undisturbed soil to a depth of approximately 5 feet and that affect its suitability for supporting low buildings with normal foundation loads.

Septic tank sewage disposal takes into account those features of the undisturbed soil that limit the absorption of effluent. Limitations are rated *slight*, *moderate*, and *severe*.

For sewage lagoons the soils are rated according to their capacity for holding sewage for the time required for bacterial decomposition. Ratings are *slight*, *moderate*, and *severe*.

Soil test data

Table 8 contains engineering test data for some of the major soils in Butler County. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Formation and Classification of Soils

In this section the factors that have affected the formation and composition of soils in Butler County are discussed. The soils are also placed in a scheme of classification.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic forces. The characteristics of the soil at any given point are determined by the five factors of soil formation. These factors are the physical and mineralogical composition of the parent material, the climate under which the soil material has accumulated and existed since accumulation, the plant and animal life on and in the soil, the relief, or lay of the land, and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and

plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. Some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

All these factors are important, but in different locations and under different conditions, some factors influence the formation of soils more than others.

The five factors are interdependent; each modifies the effect of the others. Climate and vegetation are the active forces that change the parent material and gradually form a soil. Relief, mainly through its control of runoff, influences the effect of climate and vegetation.

Parent material

In Butler County the parent material of the soils derived largely from limestone, cherty limestone, shale, and alluvium of various ages. In the eastern part of the county, the parent material is older than that in the western part, and it derived from hard limestone and cherty limestone interbedded with calcareous varicolored shale. The shallow Sogn soils and the moderately deep Labette soils formed over limestone. The cherty, but deep, Florence soils formed in cherty limestone. The more weatherable limestone has weathered into the reddish clay subsoil of the Florence soils, leaving the less weatherable chert rubble in the solum.

The Clime and Benfield soils formed in material weathered from clayey shale in the eastern half of the county.

Some soils apparently formed in material derived from more than one source. For example, the lower part of the Dwight and Irwin soils appears to have formed from shale, but in many places the upper part probably formed from transported material. Also, the parent material of the Norge and Vanoss soils is apparently both alluvial and eolian material.

Such soils as those in the Tully series formed in colluvium or slope wash. Tully soils formed on foot slopes in slope wash material, mostly derived from limestone and shale.

In the south-central part of the county, belts of gravelly terraces border the major streams at elevations of 50 to 150 feet or more above the flood plains. The thickness of the alluvial material that forms a mantle on these terraces ranges from a few inches to about 16 feet. The dominant soil on these gravelly terraces is Olpe cherty silty clay loam.

Eolian deposits in Butler County are less than 5 feet thick in most places. Because the deposits are thin, it is difficult to determine the total influence on the soils in the county. Ladysmith soils apparently formed in eolian material, but this is difficult to prove. In places the surface layer of the Irwin soils appears to have a thin veneer of loess.

Goessel soils formed in clayey sediment that appears to be of old alluvial origin, probably of Pleistocene age.

Rosehill soils formed in material weathered from alkaline clayey shale in the western part of the county. The surface layer of Rosehill soils may have developed in clayey alluvial material. A few quartzite pebbles occur in the surface layer in places.

Alluvium is the parent material of all the soils that formed on the flood plains and stream terraces of the major streams in the county. This soil material ranges from silt loam on the first bottoms to silty clay in the backwater sediment areas.

The texture, position, and age of the alluvium influence the soil profile. The Verdigris, Brewer, and Osage soils formed in alluvium.

Climate

The climate of Butler County is subhumid. The average annual precipitation is about 32 inches. Summers are warm and winters are cool.

Climate influences both the physical and chemical weathering processes in the parent material. The percolation of water is a major factor in transforming the parent material into a soil with distinct horizons. The amount of water that will percolate through the soil depends on the amount, type, and intensity of precipitation, humidity, relief, temperature, and the nature of the soil materials. In some soils the processes of percolation are impeded as a result of erosion, excessive runoff, slope, and slow rate of water intake, so that little leaching of bases has occurred. Such is true of Clime soils. Clime soils are calcareous at or near the surface.

Soil-forming factors are most active when the soil is warm and moist. A lack of rainfall for long periods aids in soil development. When they are dry, many of the clayey soils crack; this increases movement of water through the soils when it rains. Climate indirectly affects many soils that formed in alluvium, for in periods of excessive rain, the streams overflow their banks and deposit silt on some of the soils of the valleys.

The structure of the soil is modified by freezing and thawing. Freezing and thawing of clayey soils tend to break down surface clods, and they make the soils more susceptible to blowing. This is particularly noticeable in the Goessel and Rosehill soils. In cultivated fields after freezing and thawing during the winter, the surface layer often forms fine discrete granules. After tillage and wet periods, much of this aggregation is destroyed. The alternate wetting and drying, freezing and thawing is an important part in the process of soil formation in this county.

Climate is a very important factor in causing wide differences in soils over a large area, but differences in soils as a consequence of climate in a small area such as Butler County are slight.

Plant and animal life

Of all the living organisms that function in the formation of soil, the effect of vegetation is most easily recognized. Prairie grasses provided the organic matter that has accumulated in the soils of Butler County. This organic matter has caused the uppermost layers of the soil to be dark colored.

The important functions of plant and animal life in the soil-forming processes are the furnishing of organic matter and the bringing up of nutrients from the lower layers to the surface layer. The important sources of organic matter are the stems, leaves, and roots of plants. Organic material derived from these sources modifies the color, structure, consistence, and other chemical and physical properties of the soil, creating a favorable environment for biological activity. More organic matter is added where the water relationship is favorable and grasses grow luxuriant. For example, the nearly level areas of Goessel soils are commonly darker than the gently sloping areas. For years the nearly level areas had a more favorable moisture regime, more organic matter was added, and little soil was lost through erosion.

Burrowing animals aid in mixing the soil material from various soil horizons, and to some extent they bring fresh material into the surface layer. Earthworms feed on soil organic matter and thoroughly mix the soil in which they live. Earthworm activity is particularly noticeable in soils that have a high content of organic matter. The Osage, Verdigris, and Brewer soils have signs of earthworm activity, an important part of soil development.

Relief

Relief in Butler County is a very important feature of soil formation. It tends to modify the influences of the active factors of soil formation. The influence of relief upon soil formation results from its controlling effect on drainage, runoff, and other water effects, including geologic and accelerated erosion. The amount of water that moves through the soil depends partly on relief. As a rule, less water enters the soil on steep slopes and more soil material is removed through erosion than on gentle slopes. A low flat relief generally means that the soil receives extra water in the form of runoff from higher areas. This additional water results in gray or mottled colors or in higher amounts of organic matter in the surface layer. Nearly level soils on uplands generally have a more strongly developed profile than the steep soils. There is a slower rate of runoff in level areas, which allows more water to percolate through the soil, and less soil is removed from the surface.

The process of erosion has been active during the formation of some sloping soils. Clime soils, for example, have slopes of 3 to 15 percent. On these slopes, with material weathered from soft shale as parent material, the erosion process has been active. Because of the relief where they occur and the nature of the parent material, Clime soils are calcareous. In other areas where parent material is similar but where slope is less and relief is smoother, a leached soil, such as Benfield, has formed.

Time

Time as a factor in soil formation cannot be measured strictly in years. The length of time necessary for a soil to develop depends upon the other factors of soil formation. If the other factors have not operated long enough for definite genetic horizons to form, the soil is considered young, or immature. Mature soils have approached equilibrium with the environment and tend to have well-defined horizons.

Most of the soils of Butler County have well-defined horizons. Examples are the Irwin, Tully, Florence, Ladysmith, and Labette soils on uplands. Vanoss and Norge soils are younger, though they have well-expressed horizons. Sogn soils have been developing a long time; but their horizons are not so well expressed, because their parent material is resistant to weathering and because geologic erosion has removed soil material almost as fast as it formed. Verdigris soils on the bottom lands have been developing for only a short time, and their profile shows little evidence of horizons.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research.

Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and revised later (*9*). The system currently used by the National Cooperative Soil Survey (*11*) was developed in the early sixties and was adopted in 1965. Supplements were issued in March 1967 and in September 1968. The system is under continual study (*8*). Readers interested in the development of the system should refer to the latest literature available.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 9 shows the classification of each soil series of the county by family, subgroup, and order, according to the current system.

ORDERS.—Soils are grouped into orders according to properties that appear to have resulted from the same processes acting to about the same degree on the parent material. Ten soil orders are recognized in the current system. They are Alfisols, Aridisols, Entisols, Histosols, Inceptisols, Mollisols, Oxisols, Spodosols, Ultisols, and Vertisols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many different climates. Two of the ten soil orders are represented in Butler County. They are Mollisols and Vertisols.

Mollisols are mineral soils that have a thick, dark-colored surface horizon containing colloids dominated by bivalent cations. They do not have features that reflect soil mixing caused by shrinking and swelling.

TABLE 9.—*Classification of the soil series by higher categories*

Soil series	Family	Subgroup	Order
Benfield	Fine, mixed, mesic	Udic Argiustolls	Mollisols.
Brewer	Fine, mixed, thermic	Pachic Argiustolls	Mollisols.
Clime	Fine, mixed, mesic	Udic Haplustolls	Mollisols
Dwight [1]	Fine, montmorillonitic, mesic	Typic Natustolls	Mollisols.
Florence	Clayey-skeletal, montmorillonitic, mesic	Udic Argiustolls	Mollisols.
Goessel	Fine, montmorillonitic, mesic	Udic Pellusterts	Vertisols.
Irwin [2]	Fine, mixed, mesic	Pachic Argiustolls	Mollisols.
Labette [3]	Fine, mixed, mesic	Udic Argiustolls	Mollisols.
Ladysmith	Fine, montmorillonitic, mesic	Pachic Argiustolls	Mollisols.
Norge [2]	Fine-silty, mixed, thermic	Udic Paleustolls	Mollisols.
Olpe [4]	Clayey-skeletal, montmorillonitic, thermic	Typic Paleudolls	Mollisols.
Osage	Fine, montmorillonitic, thermic	Vertic Haplaquolls	Mollisols.
Rosehill	Fine, montmorillonitic, mesic	Udertic Haplustolls	Mollisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Tully [2]	Fine, mixed, mesic	Pachic Argiustolls	Mollisols.
Vanoss	Fine-silty, mixed, thermic	Udic Argiustolls	Mollisols.
Verdigris	Fine-silty, mixed, thermic	Cumulic Hapludolls	Mollisols.

[1] In Butler County the Dwight soils are taxadjuncts to the Dwight series because in about 80 percent of the acreage where Dwight soils are mapped, these soils are underlain by limestone at a depth of 20 to 40 inches.

[2] In this county the eroded Irwin, Norge, and Tully soils are considered taxadjuncts to their series because the Mollic epipedons have been thinned by erosion to exclude them from their series.

[3] In Butler County some of the soils in the Labette series are taxadjuncts because their surface layer is thinner than the defined range for the series.

[4] In Butler County the Olpe soils are taxadjuncts to the Olpe series because they are in areas of less rainfall than is typical for the series.

Vertisols are mineral soils that have a high content of clay throughout and show evidence of soil mixing caused by shrinking and swelling.

SUBORDERS.—Each order is divided into suborders, primarily on the basis of soil characteristics that indicate genetic similarity. The suborders have a narrower climatic range than the orders. The criteria for suborders reflect either the presence or absence of waterlogging or soil differences resulting from climate or vegetation.

GREAT GROUPS.—Suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that have a pan that interferes with the growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 9, because it is the last word in the name of the subgroup.

SUBGROUPS.—Great groups are divided into subgroups, one representing the central typic segment of the group, and the others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group.

FAMILIES.—Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

Additional Facts About the County

This section provides information mainly for those unfamiliar with Butler County. It tells about the physiography, drainage, water supply, and climate and gives facts about farming, industry, transportation, and community facilities in the county.

Physiography, Drainage, and Water Supply

Butler County lies within two resource areas. The eastern two-thirds of the county is in the Bluestem Hills resource area, and the western one-third is in the Central Loess Plains resource area. In general, soils in the western part of the county are gently sloping or slightly undulating. Those in the eastern part are strongly sloping or hilly. The eastern part of the county is included in the areas known locally as the "Flint Hills."

Elevations in Butler County range from about 1,150 feet along the Walnut River south of Douglass to about 1,664 in the southeastern part of the county. The average elevation is 1,300 feet.

The principal bodies of water are the Walnut and Whitewater Rivers. The Walnut River originates near Cassoday in the northeastern part of the county and flows in a southwesterly direction until it leaves the county south of Douglass. The Whitewater River traverses the county from the northwest and flows into the Walnut River south of Augusta. These two rivers have many tributaries in this county. The principal ones are the West Branch Walnut River, Little Walnut River, and Bemis, Bird, Cole, Durechen, Eightmile, Hickory, Muddy, Satchel, Rock, and Turkey Creeks, tributaries of the Walnut; and the West Branch, Elm, Dry, Diagonal Fourmile, Rock, Wentworth, and Henry Creeks, tributaries of the Whitewater River.

The water supply in most of Butler County is extremely variable. In the western part of the county, water for domestic and livestock use is obtained mostly from drilled wells. The dependability of the water supply generally is good and water is of fair to good quality. In the eastern part of the county, adequate drilled wells on uplands are difficult to obtain. The most dependable wells in these areas are drilled in shallow alluvial deposits in small drainageways. The water for livestock is supplied for the most part by farm ponds, pits, and intermittent streams. Wells and cisterns are the main source of livestock water around farmsteads and feedlots. Adequate supplies of water can be obtained in most of the valleys of the main streams.

Natural springs are a dependable source of water for livestock and domestic use in some parts of Butler County. Several natural springs are now used for this purpose. The largest is Cave Springs, which is south of El Dorado. Some seepy areas could be developed for water supply and would be a good source of water.

Irrigation is practiced to a limited extent during dry periods in Butler County. Sources of water are largely the upper reaches of the Whitewater River and the upper reaches of the West Branch of the Walnut River and Four-Mile Creek. Irrigation is of the supplemental type. The supply of water from streams is limited, and water often is not available when needed. The water resources of Butler County have been enhanced by the construction of numerous lakes, including the Fox, Clymer, El Dorado, Bluestem, Augusta, and Santa Fe. A total of 37 floodwater-retarding structures have been completed in the Little Walnut-Hickory Creek Watershed. In addition, two have been completed on Muddy Creek, three on Upper Fall River Watershed, 12 on Rock Creek Watershed, and two on Timber Creek.

The quality of water from streams is of concern to users. The suitability of water for irrigation purposes depends upon the content of chlorides or other salts, on the concentration of sodium, on the ratio of sodium to calcium and magnesium, on the content of bicarbonate, and on the presence of boron or other minor elements in amounts that are toxic to plants.

According to State Water Plan Studies (*6*), many of the surface and ground waters in the basin of the Walnut River contain excessive amounts of chloride and sulfate at times. Throughout the basin of the Walnut River, many of the ground-water aquifers are contaminated as the result of manmade pollution, possibly from improper practices formerly used for disposing of brine from the oil fields. In parts of the basin of the Whitewater River, the ground water contains excessive amounts of sulfate, mostly from gypsum beds common in that area. In other parts of the Walnut basin where gypsum beds do not occur, the sulfate content of ground water is of minor significance.

Waters of the Whitewater and Walnut Rivers have been found to be hard and high in content of chloride and sulfate. The chemical quality of these rivers must be classed as poor, particularly when the flow is moderate to low. Indications are that these waters have had poor chemical quality for many years. Prior to 1916, before oil production in the Walnut basin became significant, quality tests at Winfield indicated that chlorides in the Walnut River were less than 50 parts per million, much less than the U.S. Public Health Service's maximum acceptable limit of 250 parts per million for drinking water purposes. Limited tests made after 1916, in the period of rapid expansion of oil production, indicated a rapid increase in chloride concentration. By 1921, the chloride content at Winfield was observed to be in excess of 3,000 parts per million; and in that year the cities of Augusta, Douglass, El Dorado, and Winfield were forced to abandon the Walnut River as a source of municipal water supply and to develop other sources.

Climate [8]

Butler County, in the southeastern part of Kansas, has a continental climate that is characterized by large seasonal changes of temperature, warm to hot summers, moderate humidity, light precipitation in winter, considerable sunshine, moderate winds, and a pronounced rainfall maximum in late spring and early summer. The county is located in the region of prevailing westerlies, where transient low-pressure disturbances and intrusions of cold, continental air are common. Both of these influences contribute to the changeable weather pattern in the area. Temperature and precipitation data are summarized in table 10. The probabilities of freezing temperatures are shown in table 11.

The principal source of moisture for precipitation in Kansas is the Gulf of Mexico (*4*). Warm, moist air frequently flows from the Gulf across the eastern half of the State, and the collision of this air with occasional cold air outbreaks from northern latitudes accounts for a large proportion of the annual precipitation in Butler County. An average of 71 percent of the rainfall occurs during the growing season, April through September; and this distribution is of great significance to farmers. The peak in precipitation occurs in May and June, when the average total moisture for the 2 months is about 9 inches. Average rainfall in each of the months April through September is more than 3 inches. Precipitation declines after September, reaching a minimum of 0.85 of an inch in January. Winters are dry in Butler County; only about 10 percent of the total annual precipitation falls during December and February.

Showers and thundershowers during the warmer half of the year account for much of the annual precipitation. Thunderstorms in spring and summer occasionally produce heavy rain, large hailstorms, strong wind, and tornadoes. However, the violent storms that occur are usually local in extent and of short duration. These storms produce damage in a variable and spotted pattern.

Precipitation varies widely from month to month and from year to year. Some months during the period of weather records at El Dorado have had no precipitation; at the other extreme, rainfall in several months has exceeded 11 inches.

Since 1892, when weather records were first kept at El Dorado, annual precipitation has ranged from 17.41 inches in 1936 to 51.24 inches in 1951. Dry weather of several months' duration is not uncommon, and droughts extending over a period of several years occur at irregular

[8] By MERLE J. BROWN, climatologist for Kansas, National Weather Service, U.S Department of Commerce.

intervals. The drought of 1952 through 1956 was especially severe in Butler County and elsewhere in eastern Kansas.

Snowfall is light, averaging about 15 inches per year. Seasonal snowfall has been as much as 31 inches at El Dorado, but more than 25 inches during a winter season is unusual.

Because of the continental climate, the annual and diurnal temperature ranges are large. At El Dorado, average monthly temperatures range from 32.2° F. in January to 80.3° in July. For much of the year the average daily temperature variation is about 25° (table 10). Temperature extremes for the entire period of record at El Dorado are −28° and 117°.

Wind, humidity, and sunshine records are not available for Butler County; but recorded data for Wichita give a good indication of conditions in the county. The prevailing wind at Wichita is from the south and blows at a velocity of about 13 miles per hour. March and April are the windiest months, with windspeeds averaging nearly 15 miles per hour. Relative humidity ranges from 50 to 60 percent during the daylight hours and from 70 to 75 percent at night. The percent of possible sunshine increases from 59 percent during the winter months to about 73 percent in July and August, indicating considerably more cloudiness in winter than in summer.

The probabilities of the last freeze in spring and the first in fall at El Dorado are given for five threshholds in table 11. The freeze-free period in Butler County averages about 190 days and extends from about April 16 to October 23 (*3*). This long growing season minimizes crop loss from freezing weather.

TABLE 10.—*Temperature and precipitation data for El Dorado, Butler County, Kans.*

Month	Temperature				Precipitation		
	Average daily maximum [1]	Average daily minimum [1]	Two years in 10 will have at least 4 days with—		Average total [1]	One year in 10 will have—	
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—
	° F.	° F.	° F.	° F.	Inches	Inches	Inches
January	43. 2	21. 1	63	3	0. 85	0. 09	1. 86
February	48. 9	24. 6	69	8	1. 18	. 12	2. 41
March	58. 6	33. 0	78	15	1. 98	. 64	3. 46
April	69. 9	44. 5	85	29	3. 04	1. 14	5. 49
May	77. 5	53. 8	90	41	4. 71	1. 89	7. 74
June	87. 0	63. 9	100	53	4. 28	. 95	8. 49
July	92. 8	67. 8	105	59	3. 64	. 69	7. 87
August	92. 8	67. 0	105	56	3. 34	. 80	6. 15
September	84 6	58. 8	99	43	3. 71	. 73	8. 18
October	72. 7	46. 7	88	31	2. 49	. 67	6. 31
November	57. 6	33. 2	74	17	1. 83	. 03	4. 34
December	46. 3	24. 5	65	10	1. 08	. 12	2. 59
Year	69. 3	44. 9	[2] 104	[3] −6	32. 13	22. 11	45. 39

[1] Data for period 1903–60.
[2] Average annual highest temperature, 1903–66.
[3] Average annual lowest temperature, 1903–66.

TABLE 11.—*Probabilities of last freezing temperatures in spring and first in fall*

[Applicable to the central part of Butler County, Kans.]

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	March 26	April 2	April 9	April 19	April 30
2 years in 10 later than	March 20	March 27	April 4	April 14	April 25
5 years in 10 later than	March 8	March 17	March 26	April 4	April 15
Fall:					
1 year in 10 earlier than	November 14	November 4	October 28	October 16	October 9
2 years in 10 earlier than	November 20	November 9	November 1	October 21	October 13
5 years in 10 earlier than	November 2	November 20	November 11	October 30	October 23

Climatic conditions in Butler County generally are favorable for farming. The length of the growing season, the seasonal distribution of precipitation, and the percentage of possible sunshine are important climatic factors that contribute to good growth of crops in the area.

Farming

Except for narrow wooded areas, mainly adjacent to perennial streams, tall prairie grasses originally covered most of the area that is now Butler County. Early farming consisted mostly of the raising of livestock. Markets were too far away to profitably market grain except through livestock. Little sod was broken until about 1877, when a railroad was established to El Dorado.

Among the crops grown by the early settlers were winter wheat, corn, oats, rye, barley, Irish potatoes, sweet potatoes, cowpeas, soybeans, flax, broomcorn, kafir, and alfalfa. In 1908 about 78,000 acres was used to grow kafir; and during the period of 1911 to 1929, it was grown extensively.

In 1932 corn was the crop most commonly grown in this county. It was grown on nearly half again as much acreage as wheat. In that year nearly 2 million bushels of corn were produced in Butler County. Wheat and sorghum are better suited to the climate of this county, however, than corn and most other crops; and they are the main crops grown today. Alfalfa, corn, barley, soybeans, sweetclover, oats, and rye are grown to some extent. According to the Kansas State Board of Agriculture (*5*), the principal crops and the amounts of each harvested in Butler County in 1967 were: wheat, 52,000 acres; sorghum, 56,000 acres; corn, 7,500 acres; oats, 1,620 acres; barley, 1,700 acres; rye, 400 acres; soybeans, 10,800 acres; alfalfa cut for hay, 28,300 acres; sorghums for silage, 10,000 acres; sorghums for forage, 1,900 acres; and corn for silage, 2,000 acres.

In 1932 nearly 116,000 head of livestock were in the county, mainly in the eastern part. At this time owners of cattle shipped their stock from the ranges of Texas and fattened them for market.

Livestock is still a major source of income in Butler County. Of the kinds of livestock raised, beef cattle are, by far, the most important as a source of income. According to the Kansas State Board of Agriculture (*5*), the following were approximate numbers of livestock on farms in the county in 1968: milk cows, 3,400; other cattle, 146,600; hogs, 43,000; sheep and lambs, 4,000; and chickens, 86,000.

Industry

Oil is the major industry in Butler County. At the El Dorado field, discovered in 1915, 260,296,633 barrels of crude oil had been produced as of January 1, 1965. This oil was taken from 1,570 producing wells covering 25,670 acres. The four refineries that operate in Butler County have a capacity of approximately 120,000 barrels per day.

Transportation

U.S. Highway Nos. 54 and 77, Interstate Highway No. I–35 (Kansas Turnpike), State Highways Nos. 177, 196, and 254 provide quick and convenient access to markets. The turnpike places El Dorado within 30 minutes driving time of Wichita and within 2½ hours' driving time to Kansas City. Driving time to the State Capital, the State University, and to other cities and highway connections in between is even less. The Oklahoma I–35 highway connecting with the south terminus of the Kansas Turnpike, brings markets in the Oklahoma City area within comparable driving time with those of Kansas City.

Butler County is served by several railroad lines. Two municipally owned airports are located in the county. One is near El Dorado, and the other is near Augusta. El Dorado is within 45 minutes' driving time of the Wichita municipal airport.

Community Facilities

All rural areas in the county are included in unified elementary and high school districts. The Butler County Community Junior College is located along the west edge of El Dorado. All towns in the county are served by one or more churches. Hospital facilities are available in El Dorado.

Public recreation within the county includes facilities for boating, fishing, sailing, swimming, and picnicking. Baseball and softball diamonds are readily available for those interested in these sports. Golf courses and tennis courts are located in the larger towns.

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Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Bedding. Plowing, grading, or otherwise elevating the surface of a flat field into a series of broad beds, or "lands," so as to leave shallow surface drains between the beds

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clayey soil. As used in this soil survey, a soil that contains more than 25 percent clay.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. It may be limited either by the infiltration capacity of the soil or by the rate at which water is applied to the surface soil.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, slow, medium, rapid,* and *very rapid.*

Leached layer. A layer from which the soluble materials have been dissolved and washed away by percolating water

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

Mottling, soil. Irregular marking with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition

Parent material. Disintegrated and partly weathered rock from which soil has formed

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid.*

pH value. A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Plowpan. A compacted layer formed in the soil immediately below the plowed layer.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Runoff (hydraulics). The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on relatively steep slopes and in swelling clays, where there is marked change in moisture content.

Slick spots. Small areas in a field that are slick when wet because they contain excess exchangeable sodium, or alkali.

Slope. In this soil survey, the following are the classes of slope and their limits: Nearly level, 0 to 1 percent slopes; gently sloping, 1 to 3 percent slopes; sloping, 3 to 8 percent slopes; and strongly sloping, 8 to 15 percent slopes.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. Structureless soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particules, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till

Upland (geology). Land consisting of material unworked by water in recent geologic time and lying, in general, at a higher elevation than the alluvial plain or stream terrace. Land above the lowlands along rivers.

Weathering. All physical and chemical changes produced in rocks at or near the earth's surface by atmospheric agents. These changes result in more or less complete disintegration and decomposition of the rock.

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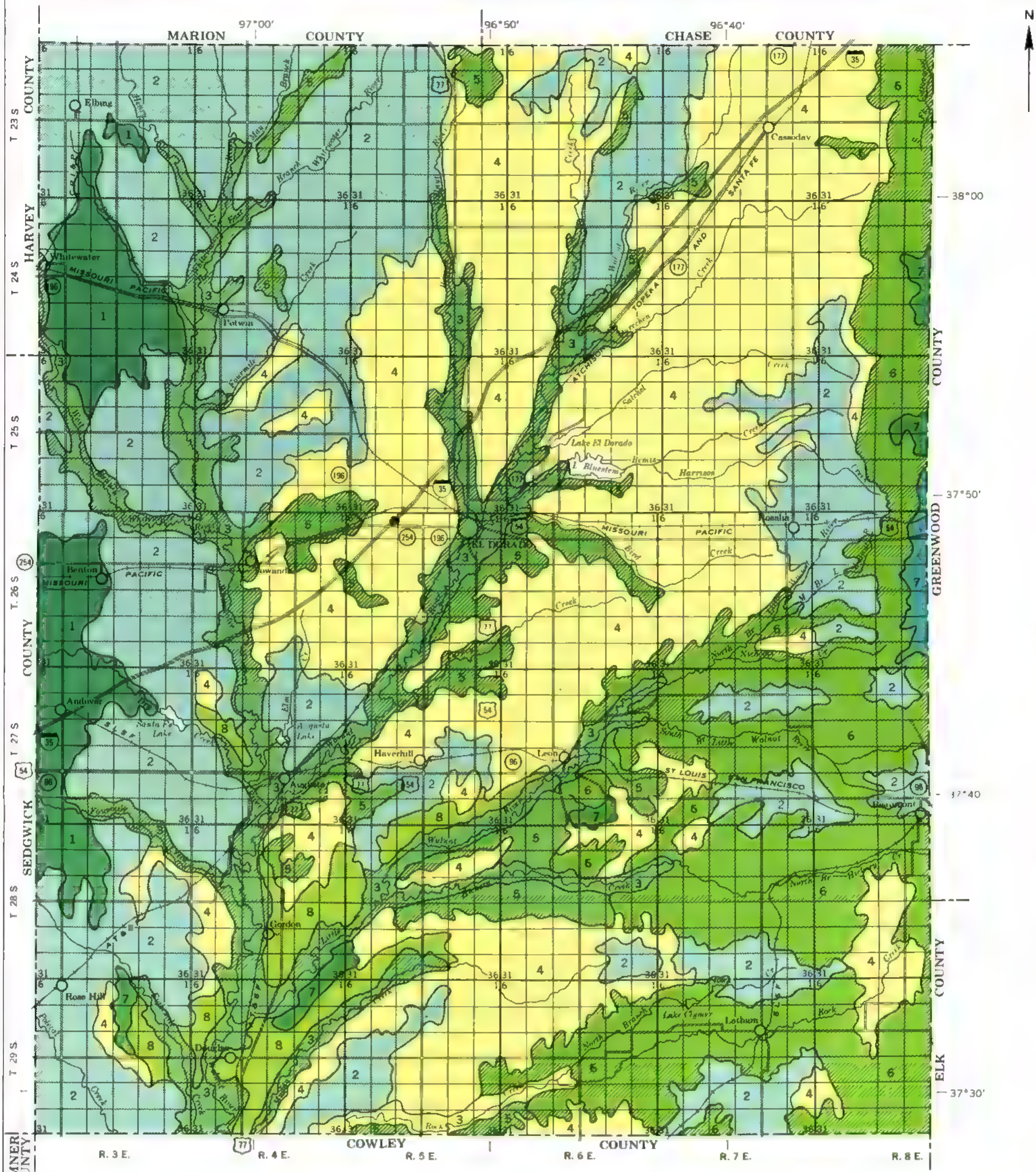
GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which it belongs. A technical description of a profile that is representative of the series is described under the soil series. Use and management of the soils for crops are described by capability units beginning on page 23. Range management is described by range sites beginning on page 31. Use of the soils as woodland and for windbreaks is described in the subsection beginning on page 34. Other information is given in tables as follows:

Acreage and extent of soils, table 1, p. 7.
Predicted yields, table 2, p. 29.
Use of the soils for wildlife, table 4, p. 38.
Interpretations for recreational uses, table 5, p. 39.
Engineering uses of the soils, tables 6, 7, and 8, pp. 42 to 51.

Map symbol	Mapping unit	Page	Capability unit		Range site		Windbreak suitability group
			Symbol	Page	Name	Page	Number
Be	Benfield-Labette cherty silty clay loams, 2 to 12 percent slopes	7	VIe-2	27	Loamy Upland	33	F
Bp	Borrow pits	7	-----	--	------------	--	---
Br	Brewer silty clay loam	8	I-2	23	Loamy Lowland	33	A
Cs	Clime-Sogn complex, 3 to 15 percent slopes	8	-----	--	------------	--	---
	Clime soils	--	VIe-3	27	Limy Upland	33	D
	Sogn soils	--	VIe-3	27	Shallow Limy	33	G
Dt	Dwight silt loam, 0 to 2 percent slopes	9	IVs-1	27	Claypan	31	E
Dw	Dwight soils, 1 to 2 percent slopes, eroded	9	VIe-4	27	Claypan	31	E
Fc	Florence cherty silt loam, 5 to 10 percent slopes	10	VIe-2	27	Loamy Upland	33	F
Go	Goessel silty clay, 0 to 1 percent slopes	11	IIs-1	24	Clay Upland	32	C
Gs	Goessel silty clay, 1 to 3 percent slopes	11	IIIe-1	24	Clay Upland	32	C
Ic	Irwin silty clay loam, 0 to 1 percent slopes	12	IIs-1	24	Clay Upland	32	C
Id	Irwin silty clay loam, 1 to 3 percent slopes	12	IIIe-1	24	Clay Upland	32	C
Ie	Irwin silty clay loam, 3 to 5 percent slopes	12	IIIe-7	26	Clay Upland	32	C
If	Irwin silty clay loam, 2 to 5 percent slopes, eroded	13	IVe-1	26	Claypan	31	E
La	Labette silty clay loam, 1 to 3 percent slopes	13	IIe-3	24	Loamy Upland	33	C
Lb	Labette silty clay loam, 1 to 3 percent slopes, eroded	13	IIIe-3	25	Clay Upland	32	C
Lc	Labette silty clay loam, 3 to 5 percent slopes	14	IIIe-8	26	Loamy Upland	33	C
Ld	Labette-Dwight complex, 1 to 3 percent slopes	14	-----	--	------------	--	---
	Labette soil	--	IIIe-2	25	Loamy Upland	33	C
	Dwight soil	--	IIIe-2	25	Claypan	31	[illegible]

Map symbol	Mapping unit	Page	Capability unit		Range site		Windbreak suitability group
			Symbol	Page	Name	Page	Number
Le	Labette-Sogn complex, 2 to 8 percent slopes	14	-----	--	------------	--	---
	Labette soil	--	VIe-1	27	Loamy Upland	33	C
	Sogn soil	--	VIe-1	27	Shallow Limy	33	G
Ls	Ladysmith silty clay loam, 0 to 2 percent slopes	15	IIs-1	24	Clay Upland	32	C
No	Norge silt loam, 0 to 1 percent slopes	15	I-1	23	Loamy Upland	33	C
Nr	Norge silt loam, 1 to 3 percent slopes	16	IIe-1	23	Loamy Upland	33	C
Ns	Norge silt loam, 3 to 5 percent slopes	16	IIIe-5	25	Loamy Upland	33	C
Nt	Norge silty clay loam, 3 to 5 percent slopes, eroded	16	IIIe-6	26	Loamy Upland	33	C
Od	Oil-waste land	16	VIIIs-1	28	------------	--	---
On	Olpe-Norge complex, 2 to 7 percent slopes	17	-----	--	------------	--	---
	Olpe soil	--	VIe-2	27	Loamy Upland	33	F
	Norge soil	--	VIe-2	27	Loamy Upland	33	C
Os	Osage silty clay	18	IIIw-1	26	Clay Lowland	32	B
Ro	Rosehill silty clay, 1 to 3 percent slopes	18	IIIe-3	25	Clay Upland	32	D
So	Sogn soils	18	VIIs-1	28	Shallow Limy	33	G
Ts	Tully silty clay loam, 1 to 4 percent slopes	19	IIe-2	24	Loamy Upland	33	C
Tt	Tully silty clay loam, 3 to 6 percent slopes, eroded	19	IIIe-7	26	Clay Upland	32	C
Tu	Tully silty clay loam, 4 to 7 percent slopes	20	IIIe-4	25	Loamy Upland	33	C
Va	Vanoss silt loam, 0 to 1 percent slopes	20	I-1	23	Loamy Upland	33	C
Vb	Vanoss silt loam, 1 to 3 percent slopes	20	IIe-1	23	Loamy Upland	33	C
Vd	Verdigris silt loam	21	I-2	23	Loamy Lowland	33	A
Ve	Verdigris soils, frequently flooded	21	VIw-1	28	Loamy Lowland	33	A



SOIL ASSOCIATIONS

1 — Goessel-Rosehill association: Nearly level and gently sloping, deep and moderately deep soils that have a silty clay surface layer and subsoil; on uplands

2 — Irwin-Ladysmith association: Nearly level to sloping, deep soils that have a silty clay loam surface layer and a silty clay subsoil; on uplands

3 — Verdigris-Brewer-Norge association: Nearly level to sloping, deep soils that have a silt loam or silty clay loam surface layer and a silty clay loam or silty clay subsoil; on flood plains and terraces

4 — Dwight-Labette association: Nearly level to sloping, moderately deep soils that have a silt loam or silty clay loam surface layer and a silty clay subsoil; on uplands

5 — Labette-Sogn association: Gently sloping to sloping, moderately deep soils that have a silty clay loam surface layer and a silty clay subsoil, and shallow soils that are silty clay loam throughout; on uplands

6 — Florence-Benfield association: Gently sloping to strongly sloping, moderately deep and deep soils that have a cherty silty clay loam or cherty silt loam surface layer and a cherty silty clay or cherty clay subsoil; on uplands

7 — Clime-Sogn association: Gently sloping to strongly sloping, moderately deep soils that have a silty clay surface layer and subsoil, and shallow soils that are silty clay loam throughout; on uplands

8 — Norge-Ladysmith association: Nearly level to sloping, deep soils that have a silt loam or silty clay loam surface layer and a silty clay loam or silty clay subsoil; on uplands and terraces

Compiled 1972

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
KANSAS AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
BUTLER COUNTY, KANSAS

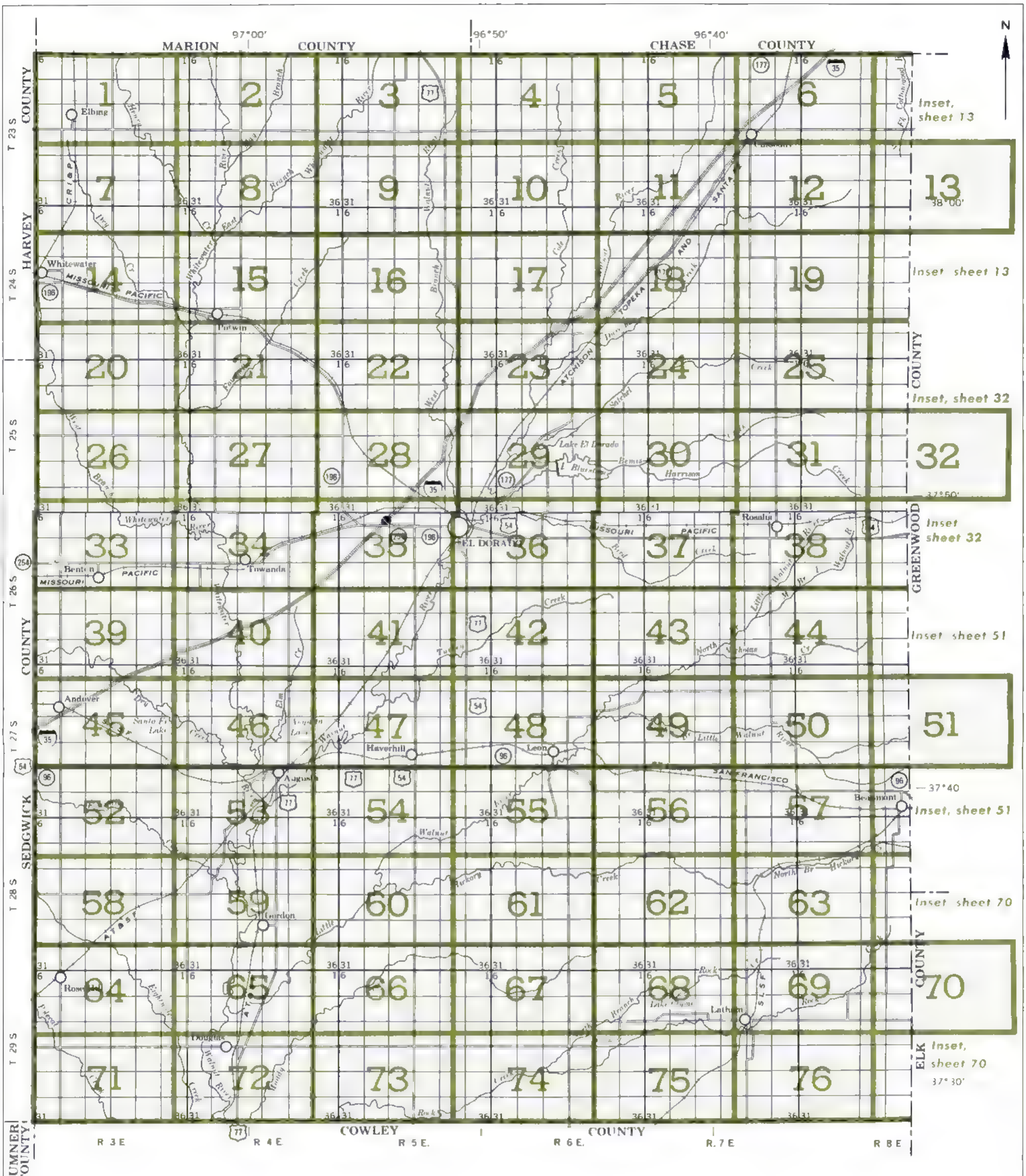
Scale 1:253,440

1 0 1 2 3 4 Miles

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36



INDEX TO MAP SHEETS

BUTLER COUNTY, KANSAS

Scale 1: 253,440

1 0 1 2 3 4 Miles

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

SOIL LEGEND

SYMBOL	NAME
Be	Benfield-Labette cherty [illegible] percent slopes
Bo	Borrow [illegible]
Br	Brewer silty clay loam
[illegible]	[illegible]me-Sogn complex, [illegible] 15 percent slopes
Dr	Dwight silt loam, 0 to 2 percent slopes
Dw	Dw[illegible] percent [illegible] eroded
[illegible]	[illegible] 10 percent [illegible]
[illegible]	[illegible] percent [illegible]
[illegible]	[illegible] percent [illegible]
[illegible]	[illegible] percent [illegible]
[illegible]	[illegible] percent [illegible]
[illegible]	[illegible] percent [illegible]
[illegible]	[illegible] percent [illegible] eroded
[illegible]	Labette silty clay loam [illegible] percent slopes
[illegible]	Labette silty clay loam [illegible] percent slopes, eroded
[illegible]	Labette silty clay loam, 3 to [illegible] percent slopes
[illegible]	Labette-Dwight complex [illegible] to [illegible] percent slopes
[illegible]	Labette-Sogn complex [illegible] 8 percent slopes
[illegible]	Ladysmith [illegible] 0 [illegible] percent slopes
[illegible]	[illegible]

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Divided
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- [illegible]
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail
- Railroad
- Ferry
- Ford
- Grade
- R. R. over
- R. R. under

Buildings
- School
- Church

Mine and quarry

Gravel pit

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout station

Windmill

Located object

BOUNDARIES

National or state

County

Minor civil division

Reservation

Land grant

Small park, cemetery, airport

Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Unclassified

Canals and ditches

Lakes and ponds
- Perennial
- Intermittent

Spring

Marsh or swamp

Wet spot

Drainage end or alluvial fan

RELIEF

Escarpments
- Bedrock
- Other

Short steep slope

Prominent peak

Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

Soil boundary and symbol

Gravel

Stony, very stony

Stoniness
- Stony
- Very stony

Rock outcrops

Chert fragments

Clay spot

Sand spot

Gumbo or scabby spot

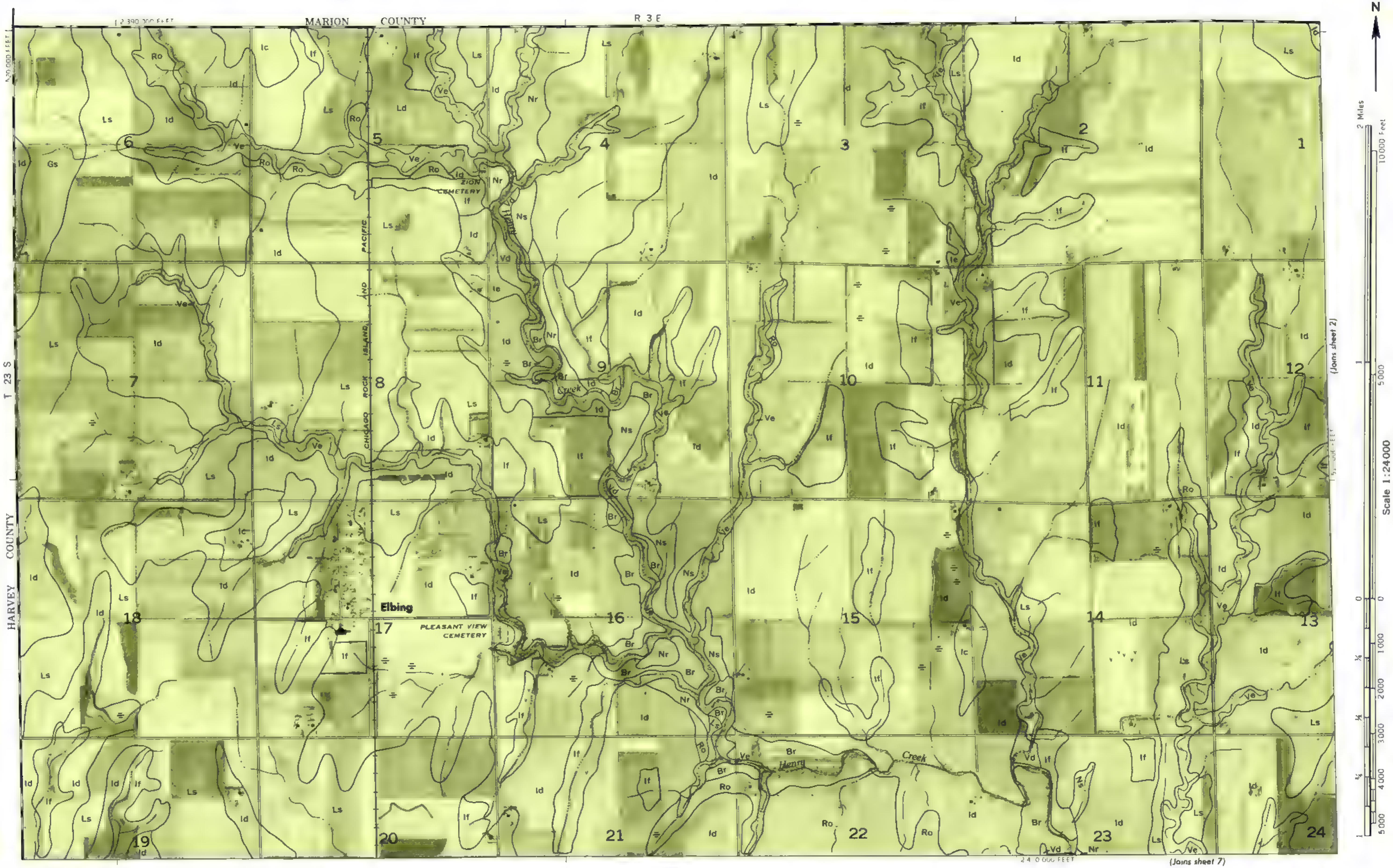
Made land

Severely eroded spot

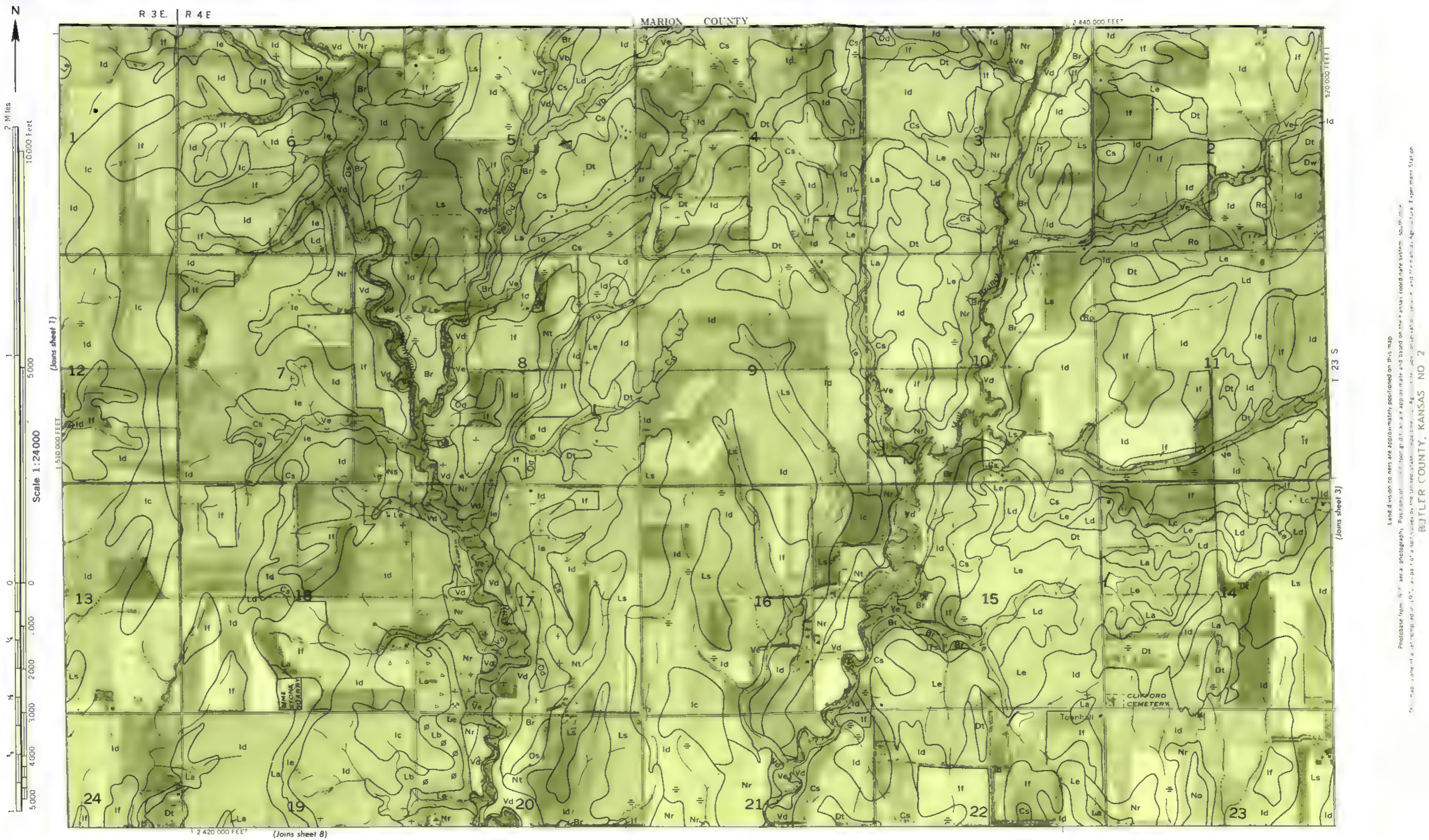
Blowout, wind erosion

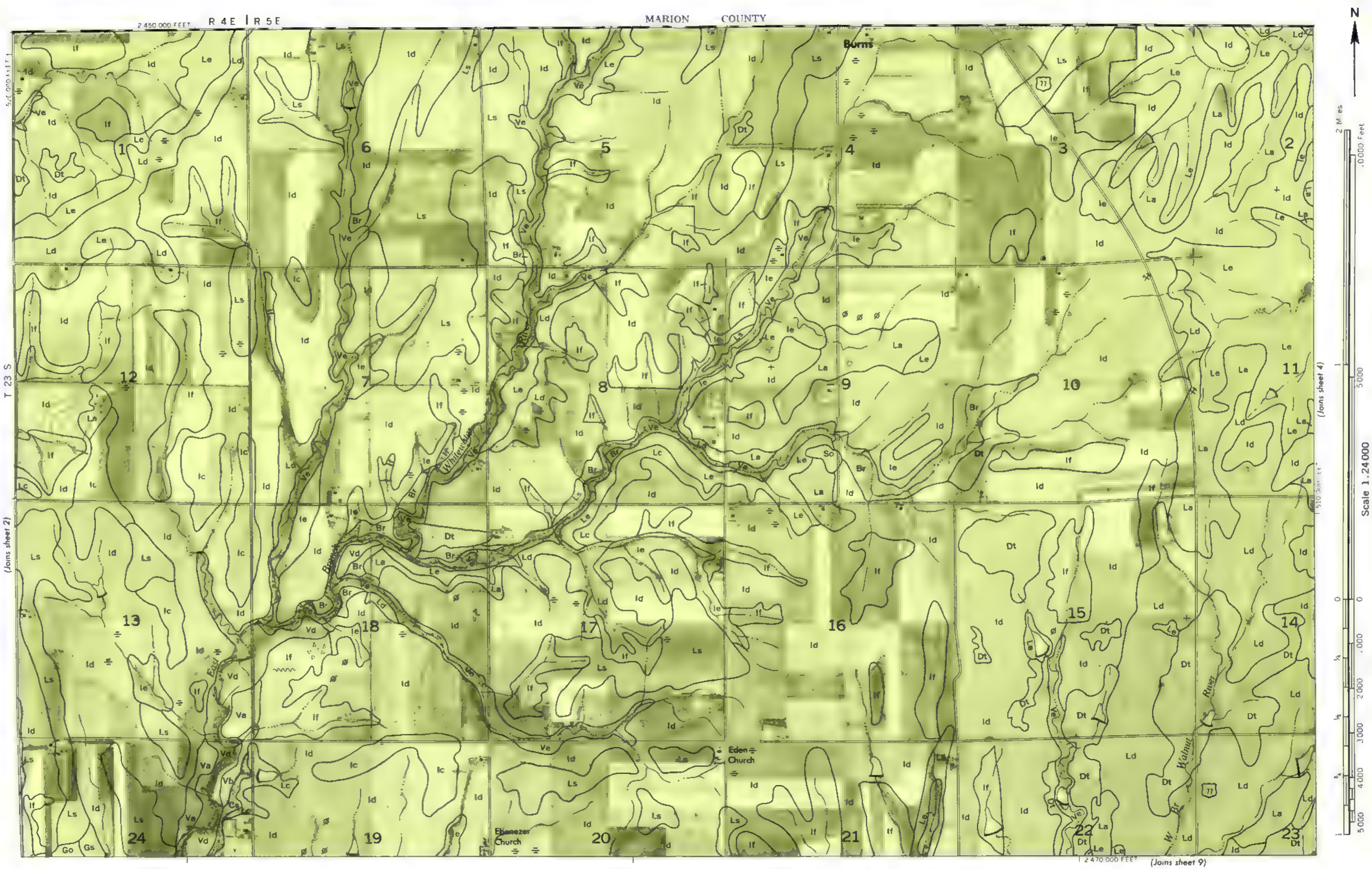
Gully

Saline spot

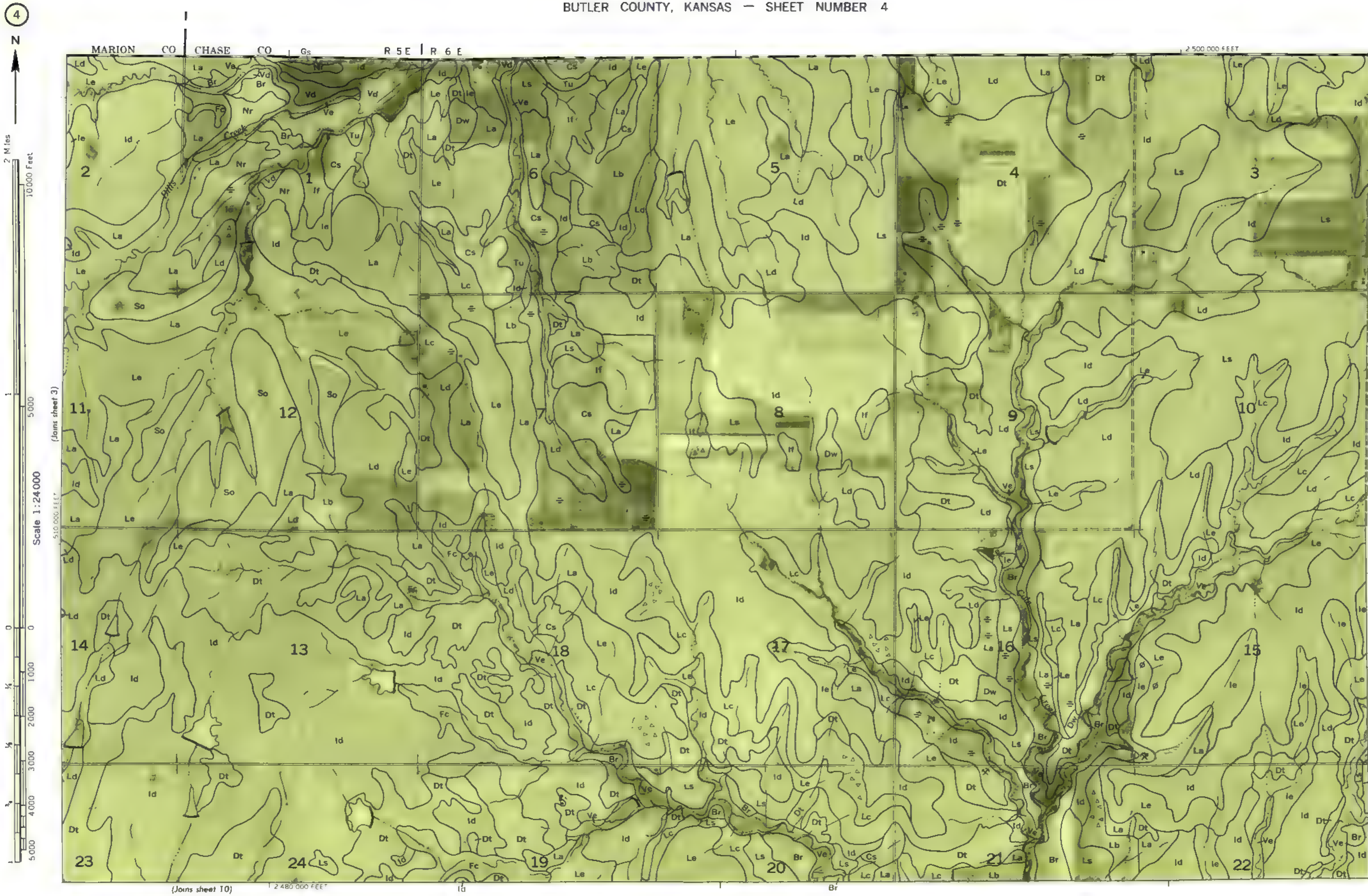

MARION COUNTY
R 3 E
T 23 S
HARVEY COUNTY
Elbing
ZION CEMETERY
PLEASANT VIEW CEMETERY
CHICAGO ROCK ISLAND AND PACIFIC
Henry Creek
(Joins sheet 2)
(Joins sheet 7)
N
Scale 1:24 000
2 Miles
10 000 Feet

BUTLER COUNTY, KANSAS — SHEET NUMBER 2




MARION COUNTY
R 4 E | R 5 E
T 23 S
Burns
Eden Church
Ebenezer Church
Whitewater River
East Branch
W. Br. Walnut River
(Joins sheet 2)
(Joins sheet 4)
(Joins sheet 9)
Scale 1:24 000
N

BUTLER COUNTY, KANSAS — SHEET NUMBER 4

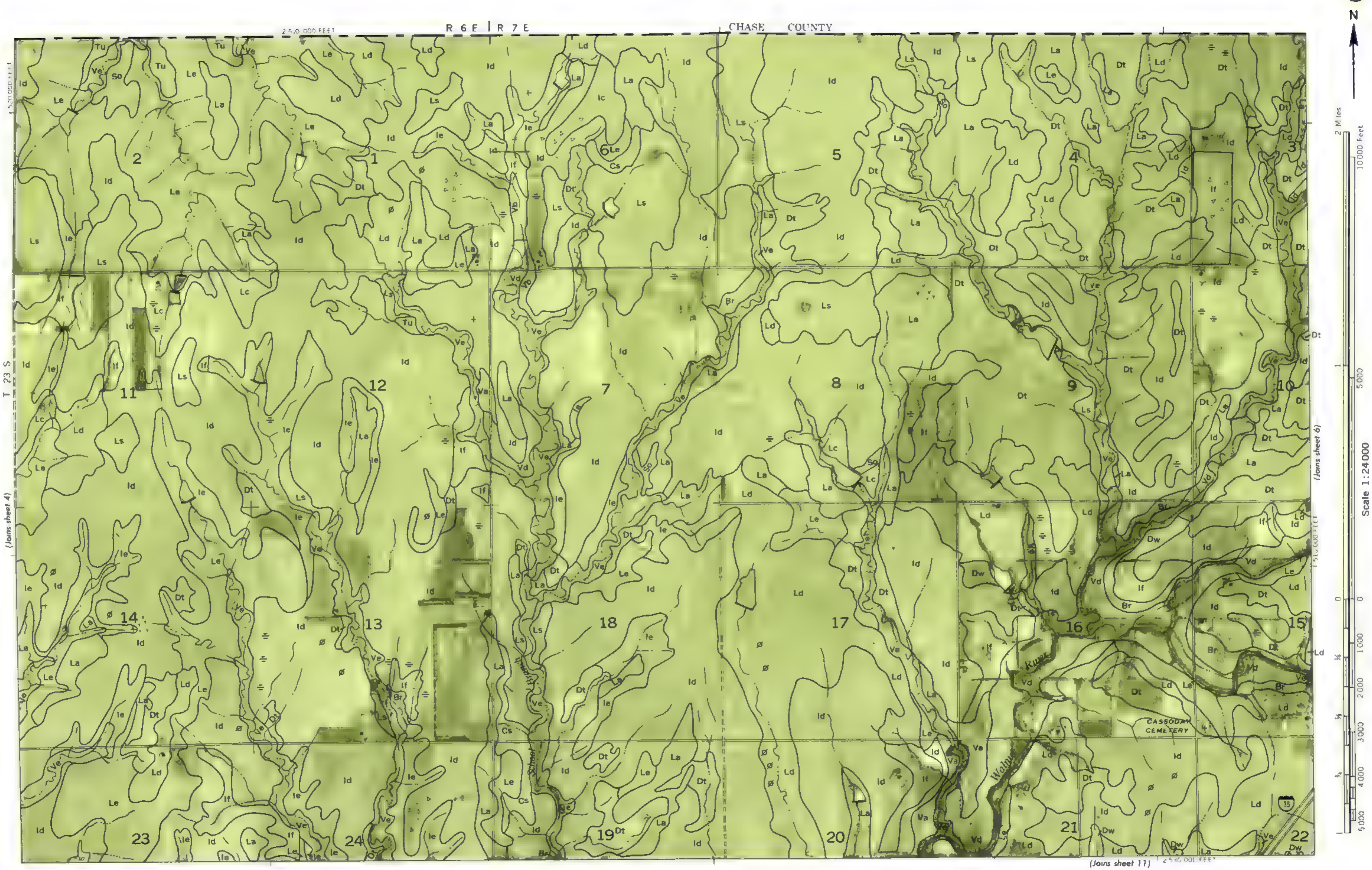


Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

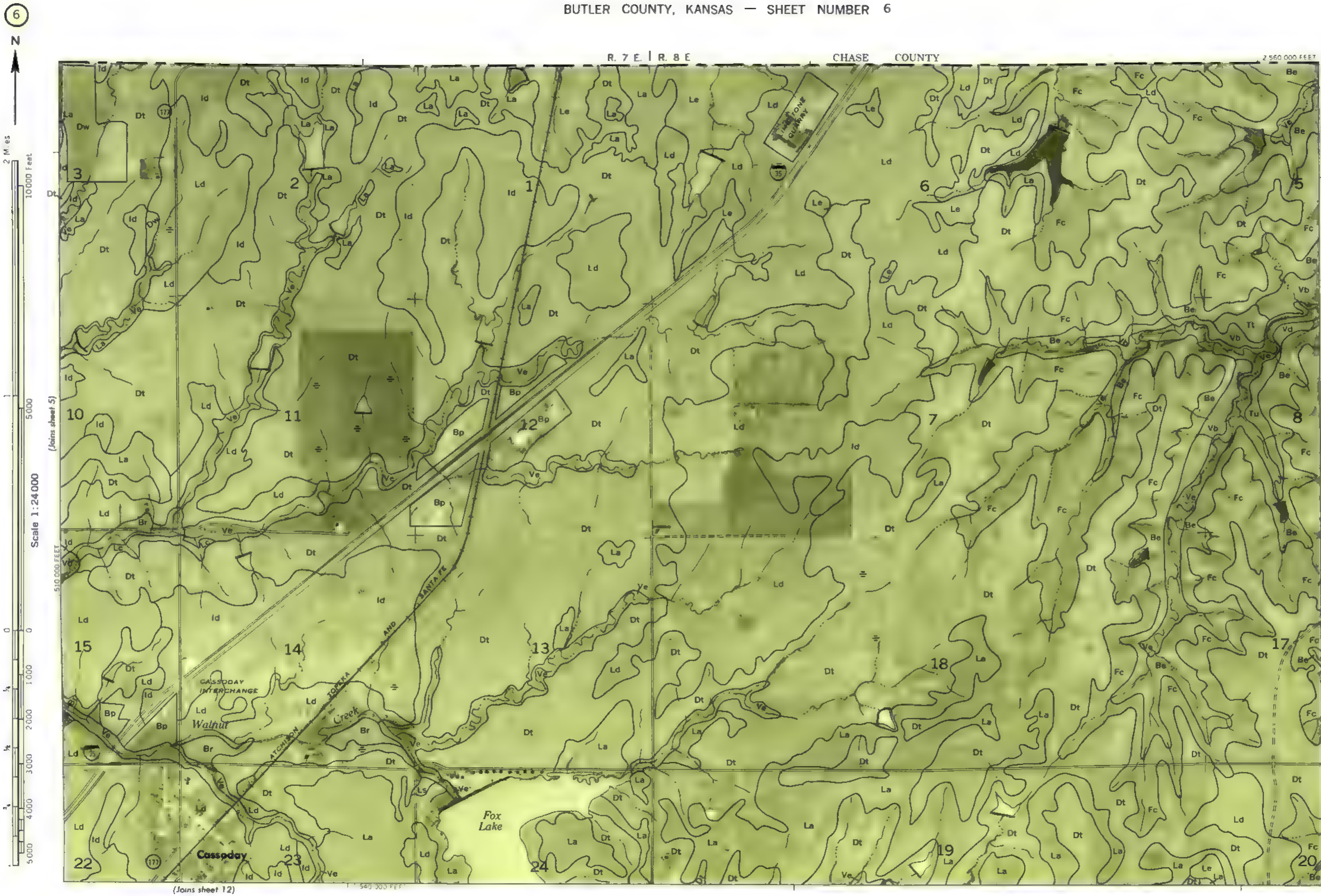
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

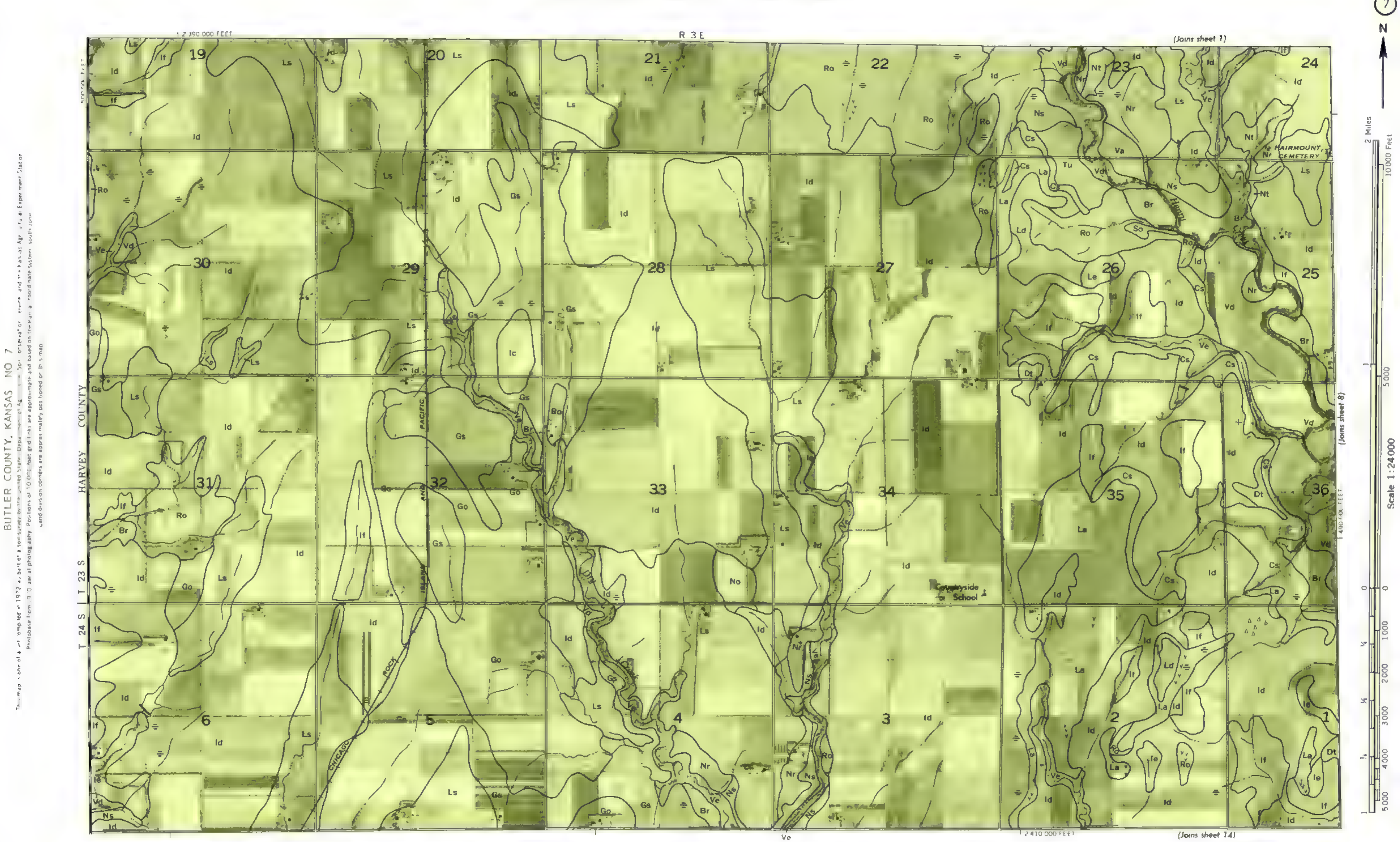
BUTLER COUNTY, KANSAS NO. 4



BUTLER COUNTY, KANSAS NO. 5

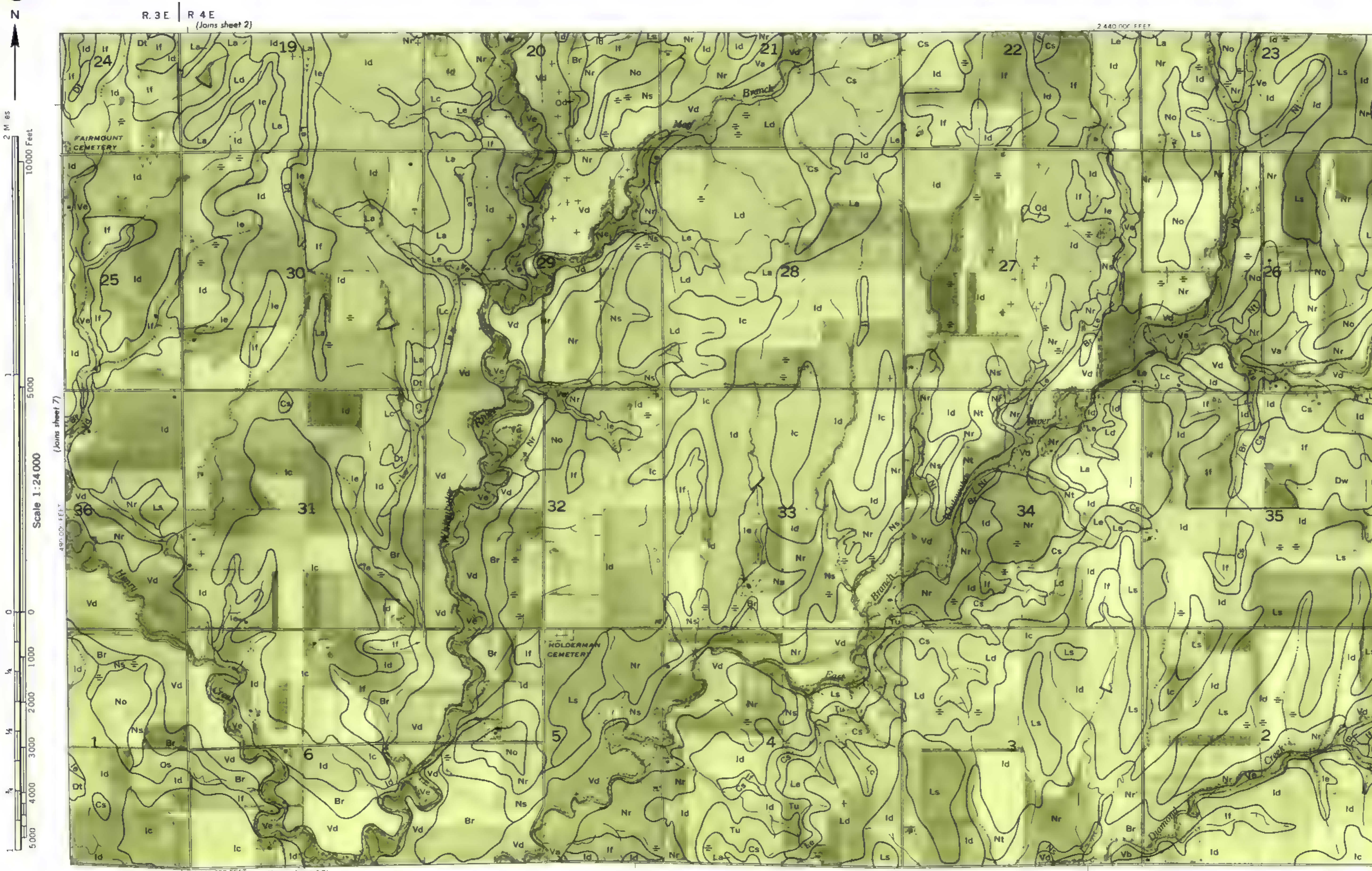
BUTLER COUNTY, KANSAS — SHEET NUMBER 6





7
R 3 E
(Joins sheet 1)
(Joins sheet 8)
(Joins sheet 14)
HARVEY COUNTY
T 23 S
T 24 S
FAIRMOUNT CEMETERY
Countryside School
CHICAGO
ROCK
ISLAND
AND
PACIFIC
N
Scale 1:24 000
2 Miles
10 000 Feet
BUTLER COUNTY, KANSAS NO. 7

BUTLER COUNTY, KANSAS — SHEET NUMBER 8



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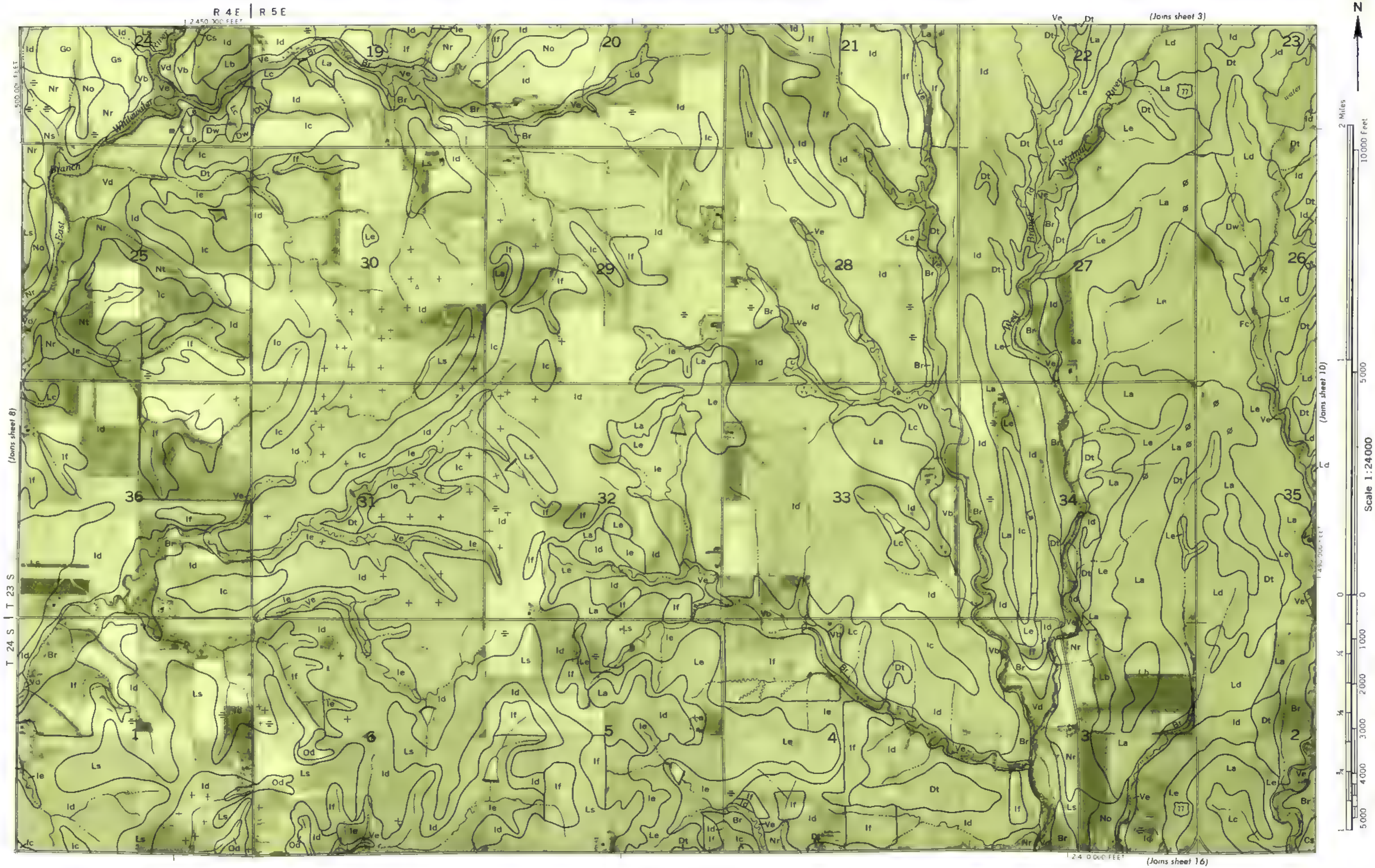
R 4 E
R 5 E
T 23 S
T 24 S
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(Joins sheet 8)
(Joins sheet 10)
(Joins sheet 16)
N
Scale 1:24000
2 Miles
10000 Feet
Whitewater River
Walnut River
19
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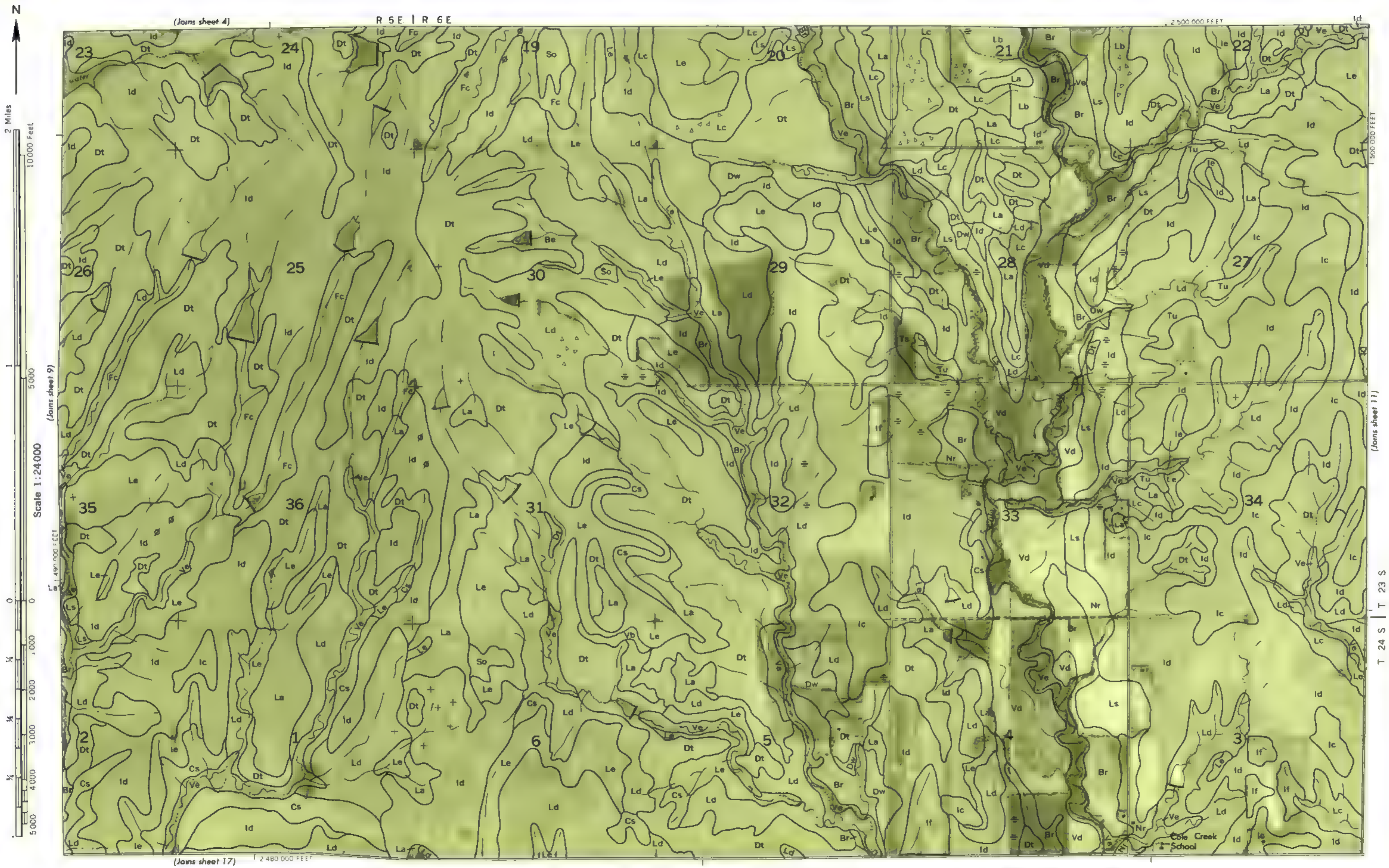

Land division corners are approximately positioned on this map.

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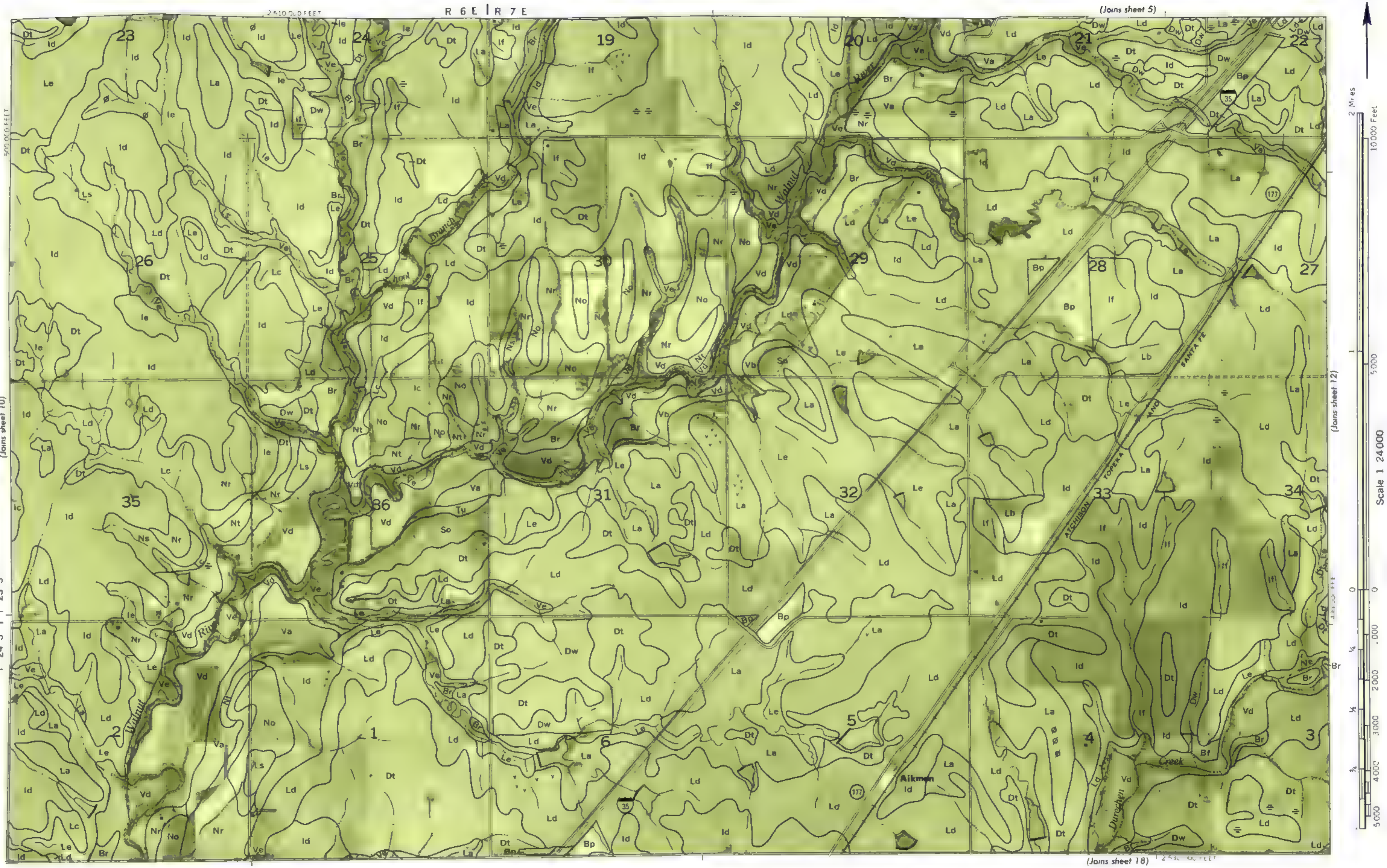

BUTLER COUNTY, KANSAS NO. 11

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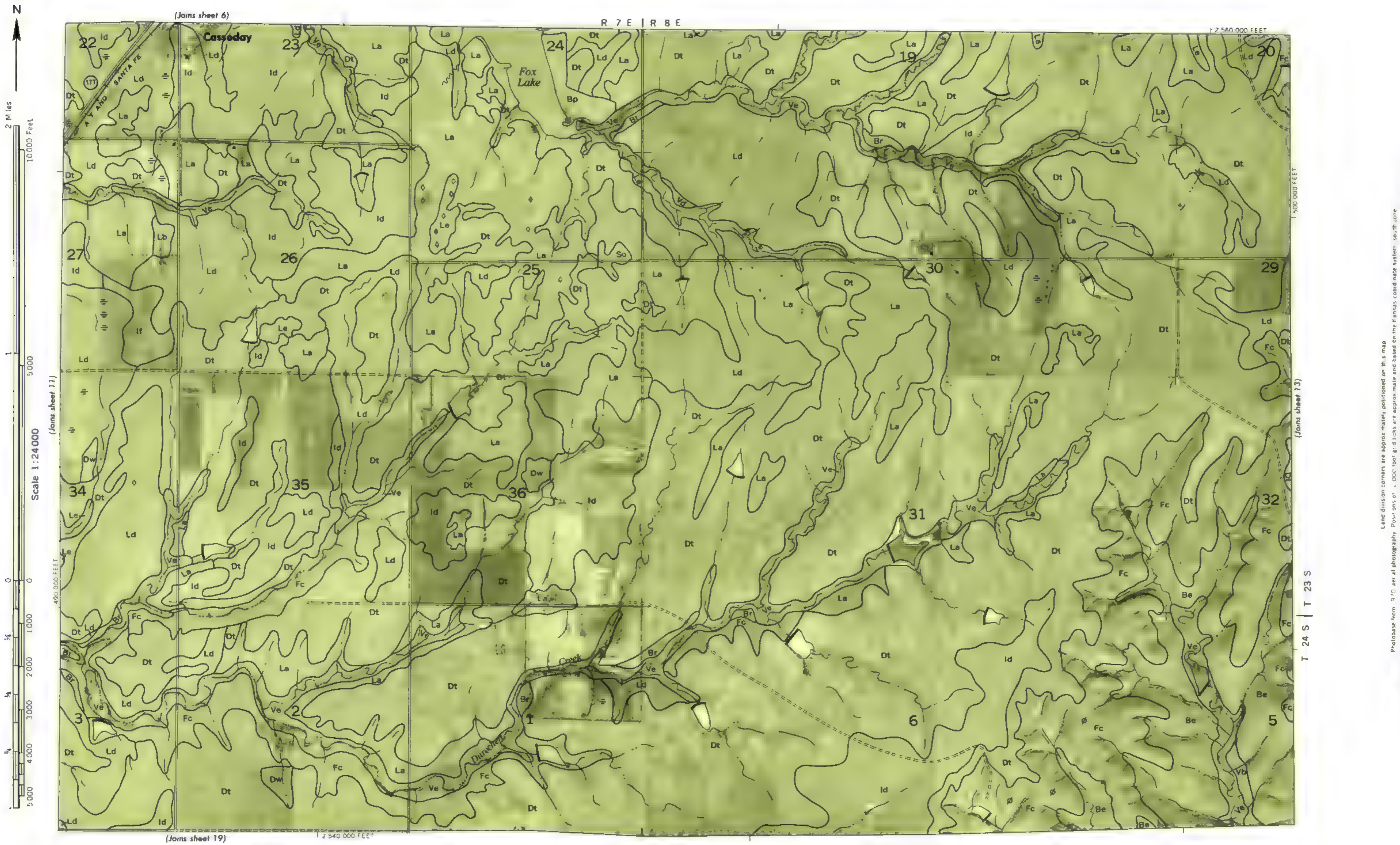
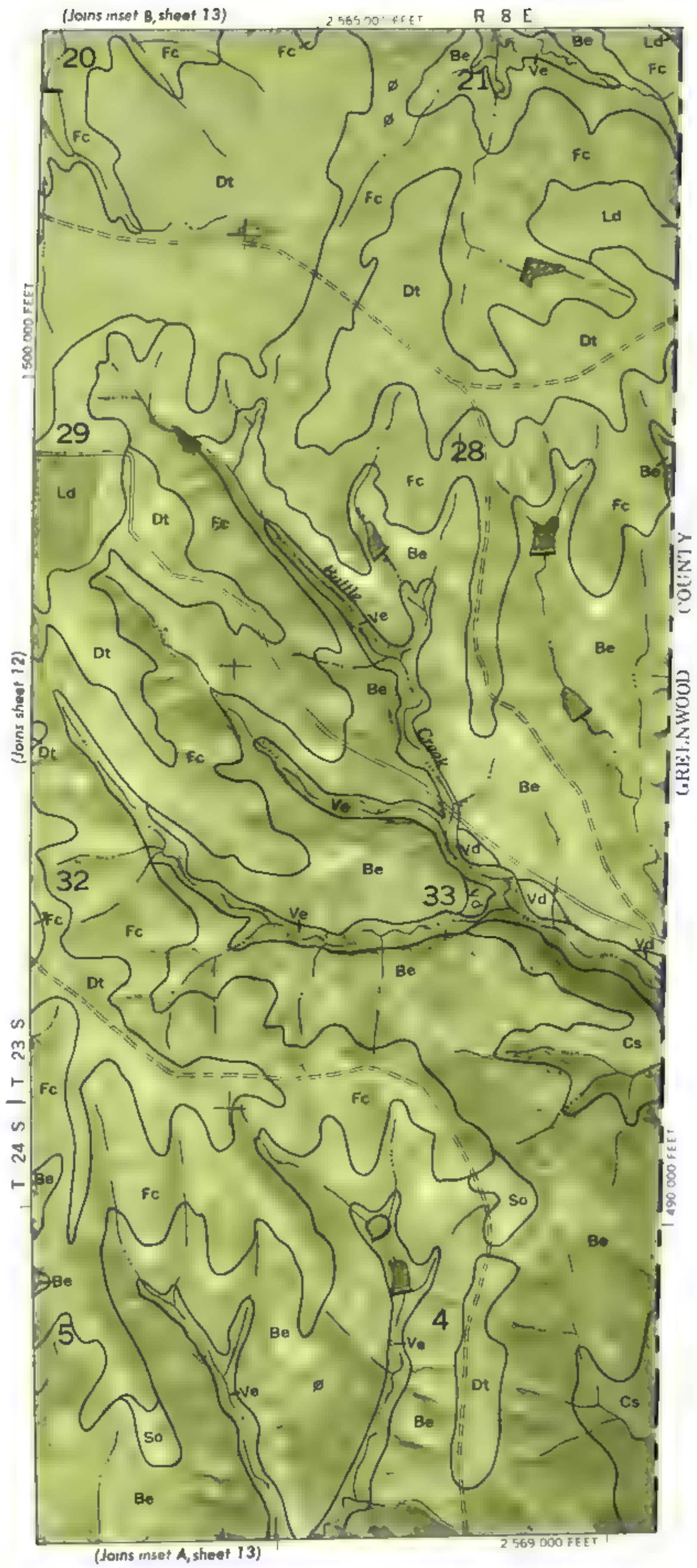
Photobase from [illegible] aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.
Land division corners are approximately positioned on this map.

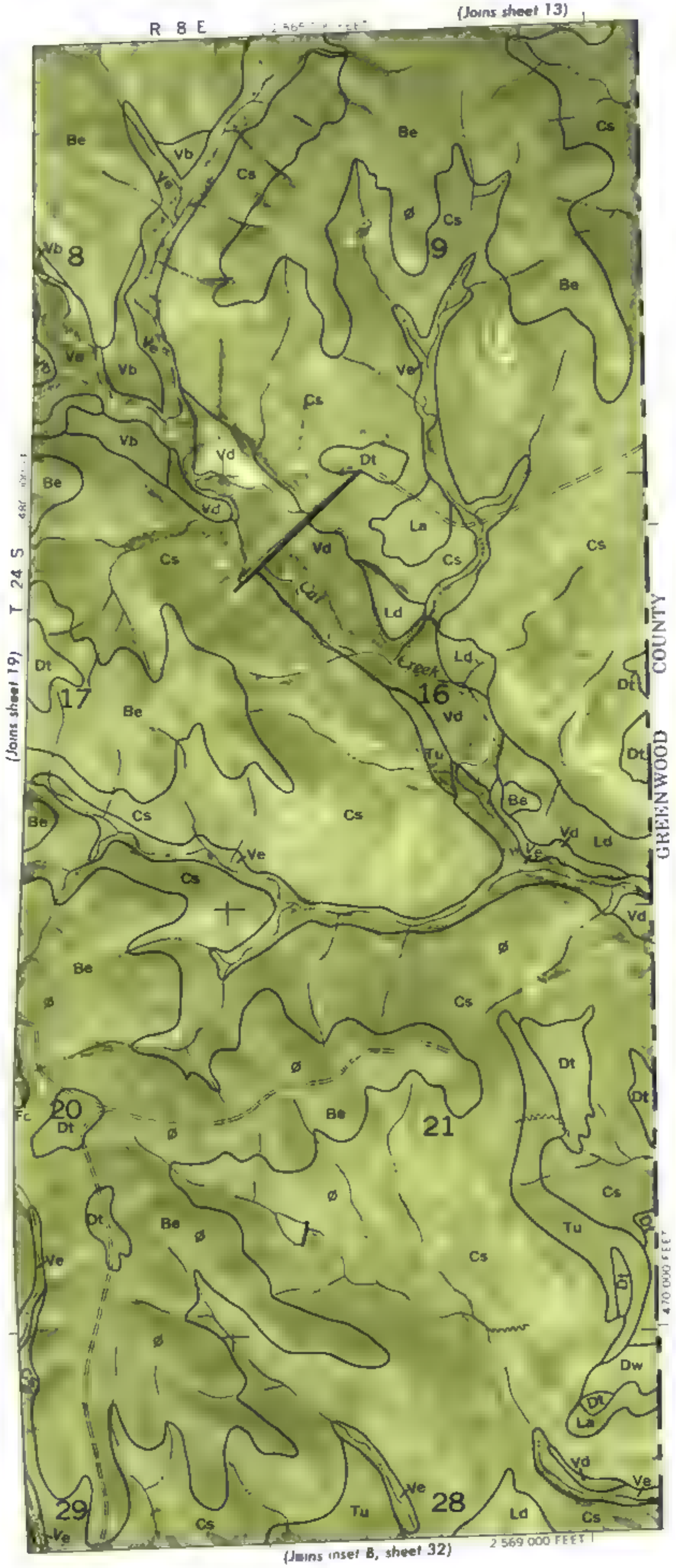
BUTLER COUNTY, KANSAS — SHEET NUMBER 12





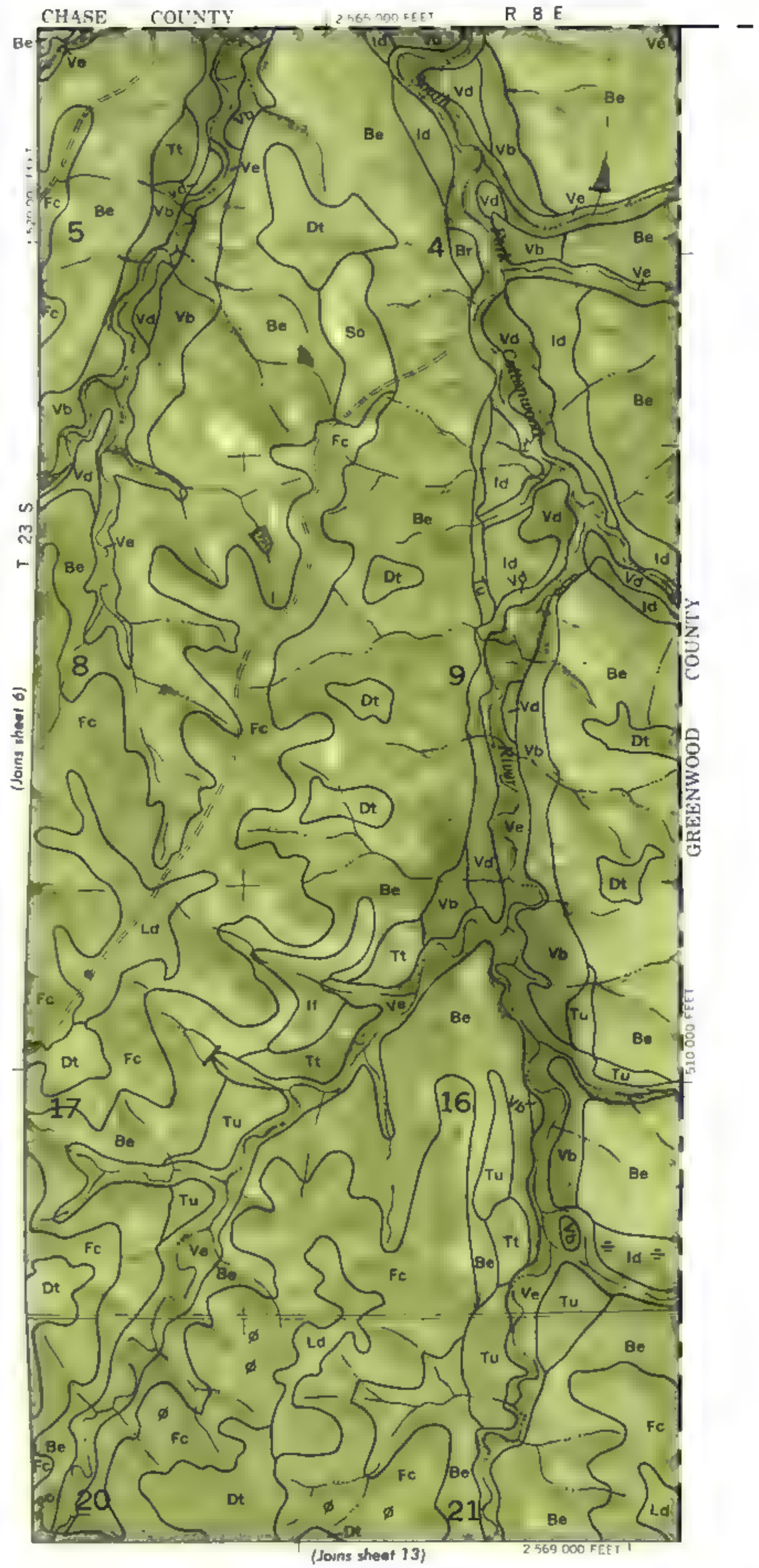
4000 AND 10000 FOOT GRID TICKS

INSET A

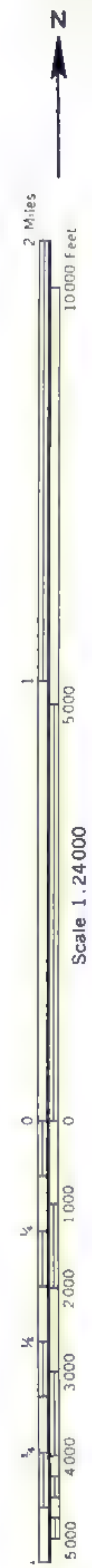


4000 AND 10000 FOOT GRID TICKS

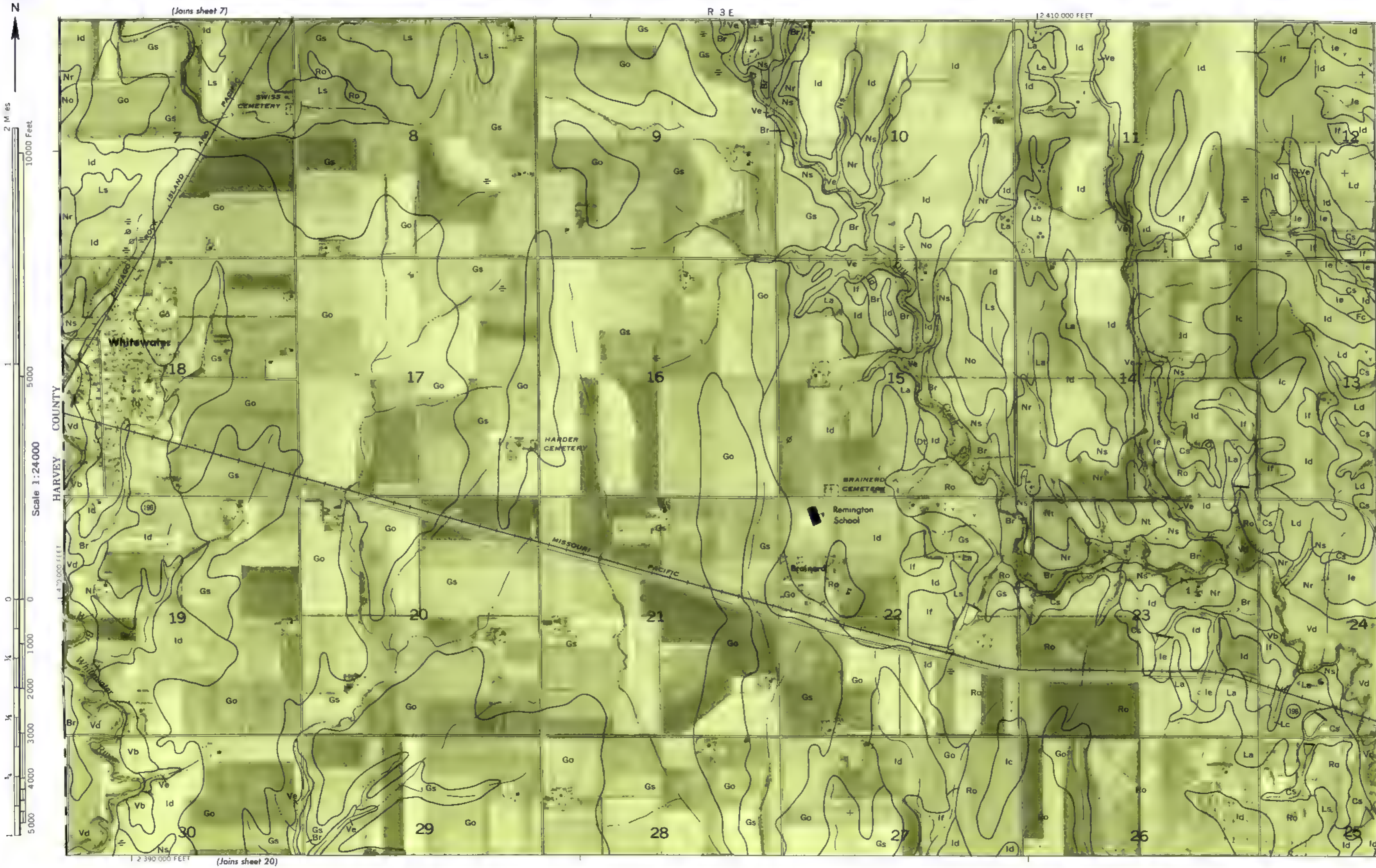
INSET B



4000 AND 10000 FOOT GRID TICKS



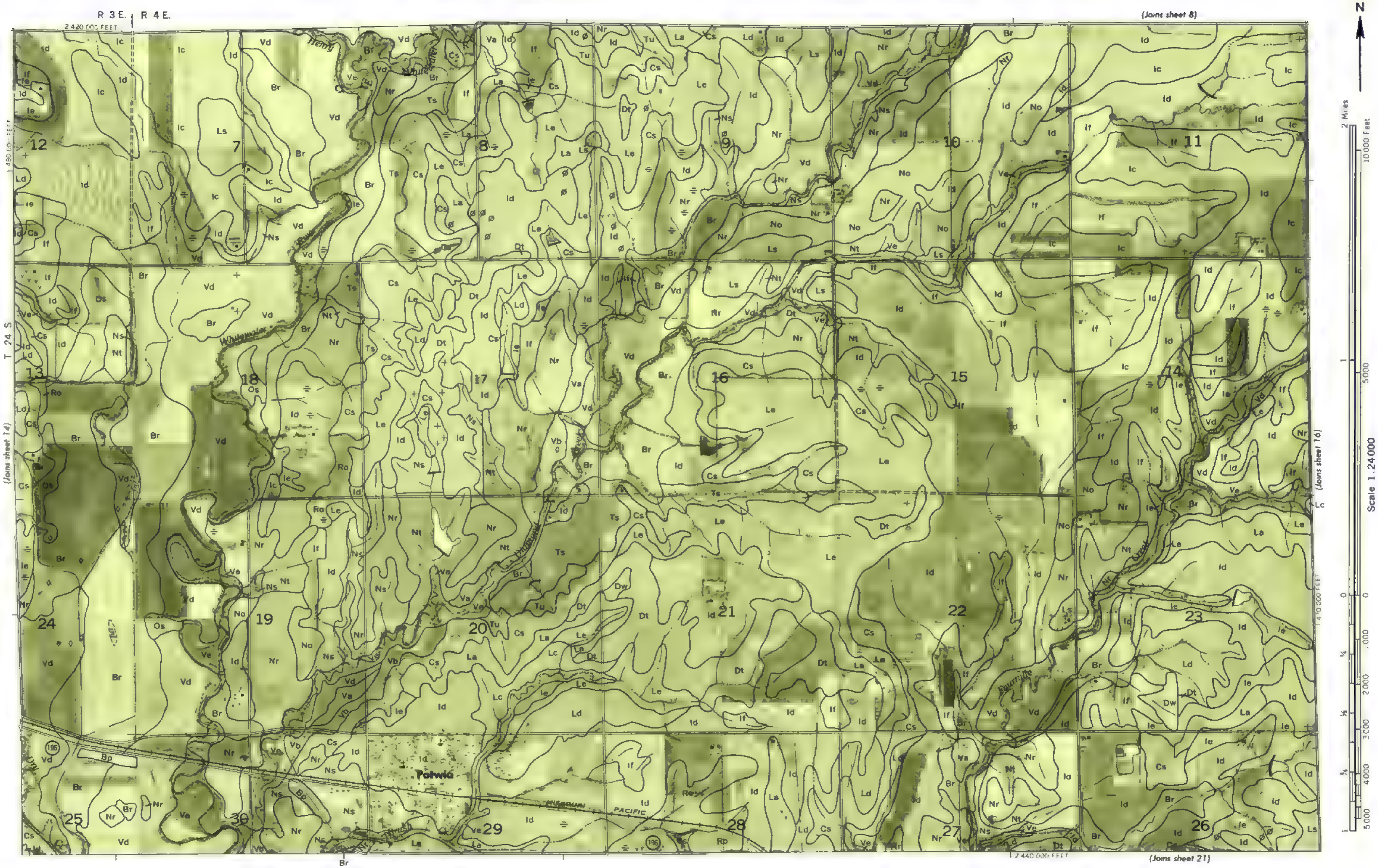
BUTLER COUNTY, KANSAS — SHEET NUMBER 14



Land division corners are approximately positioned on this map.

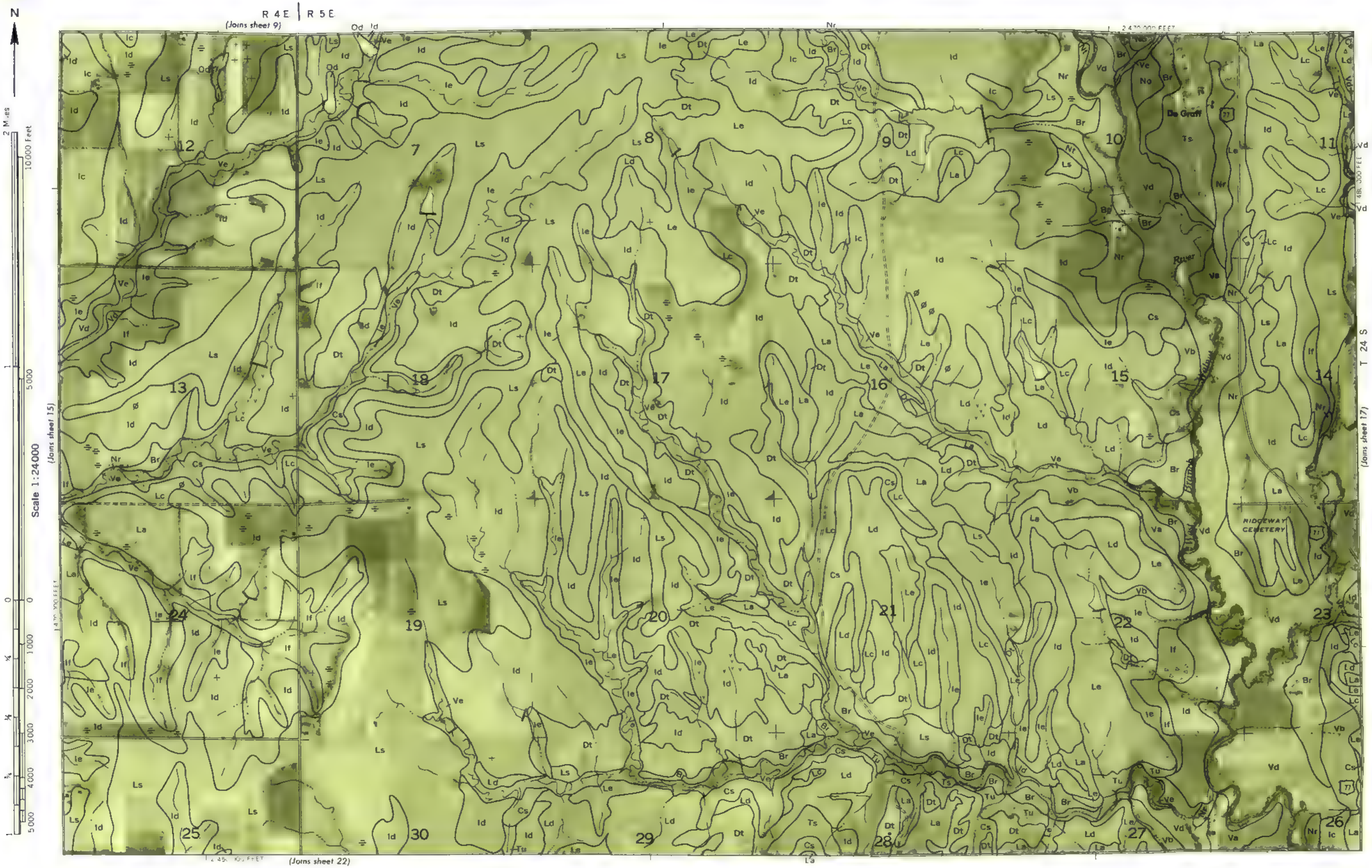
Photobase from 1970 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



BUTLER COUNTY, KANSAS NO 15

Land division corners are approximately positioned on this map

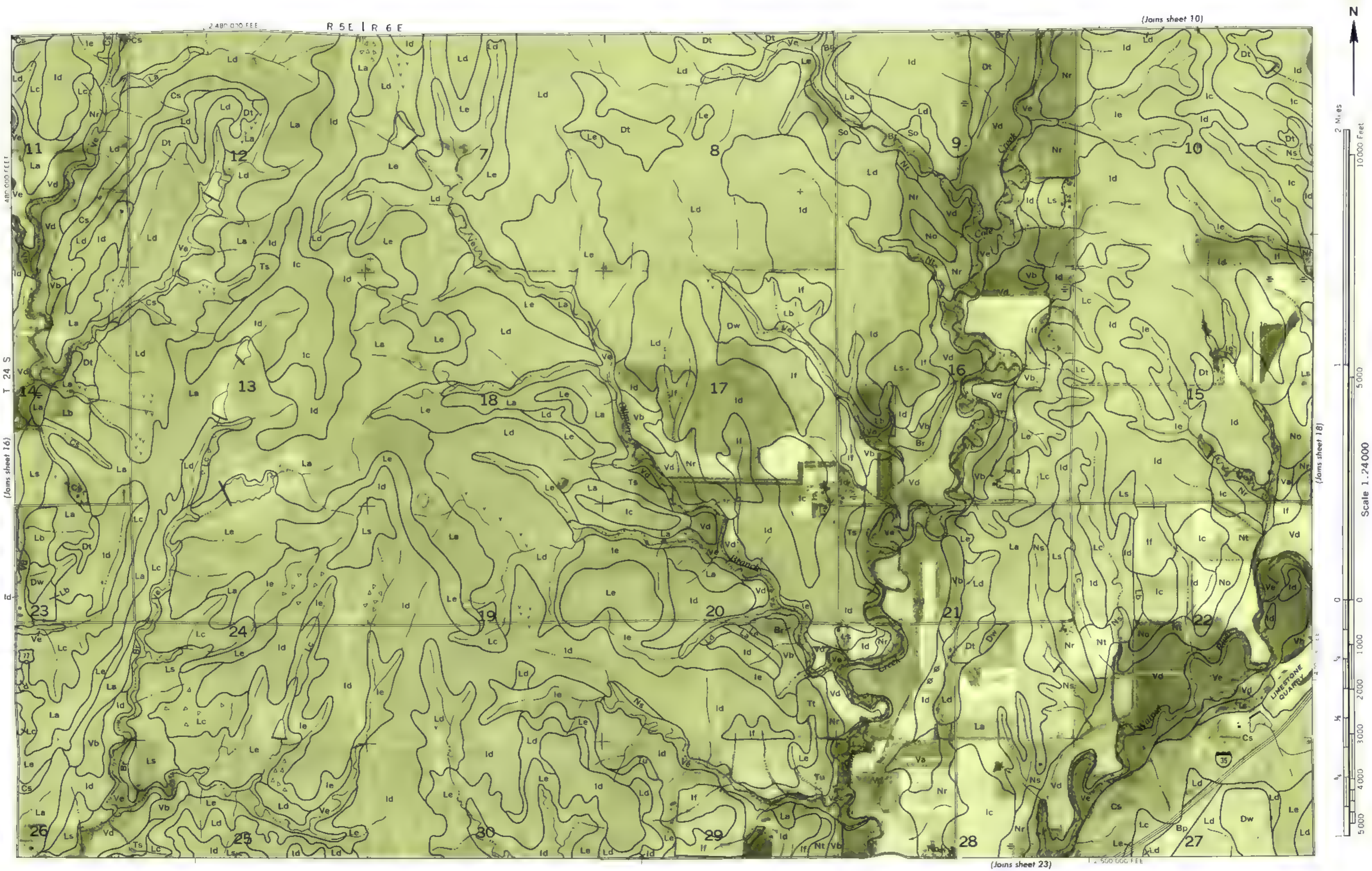


Land division corners are approximately positioned on this map.

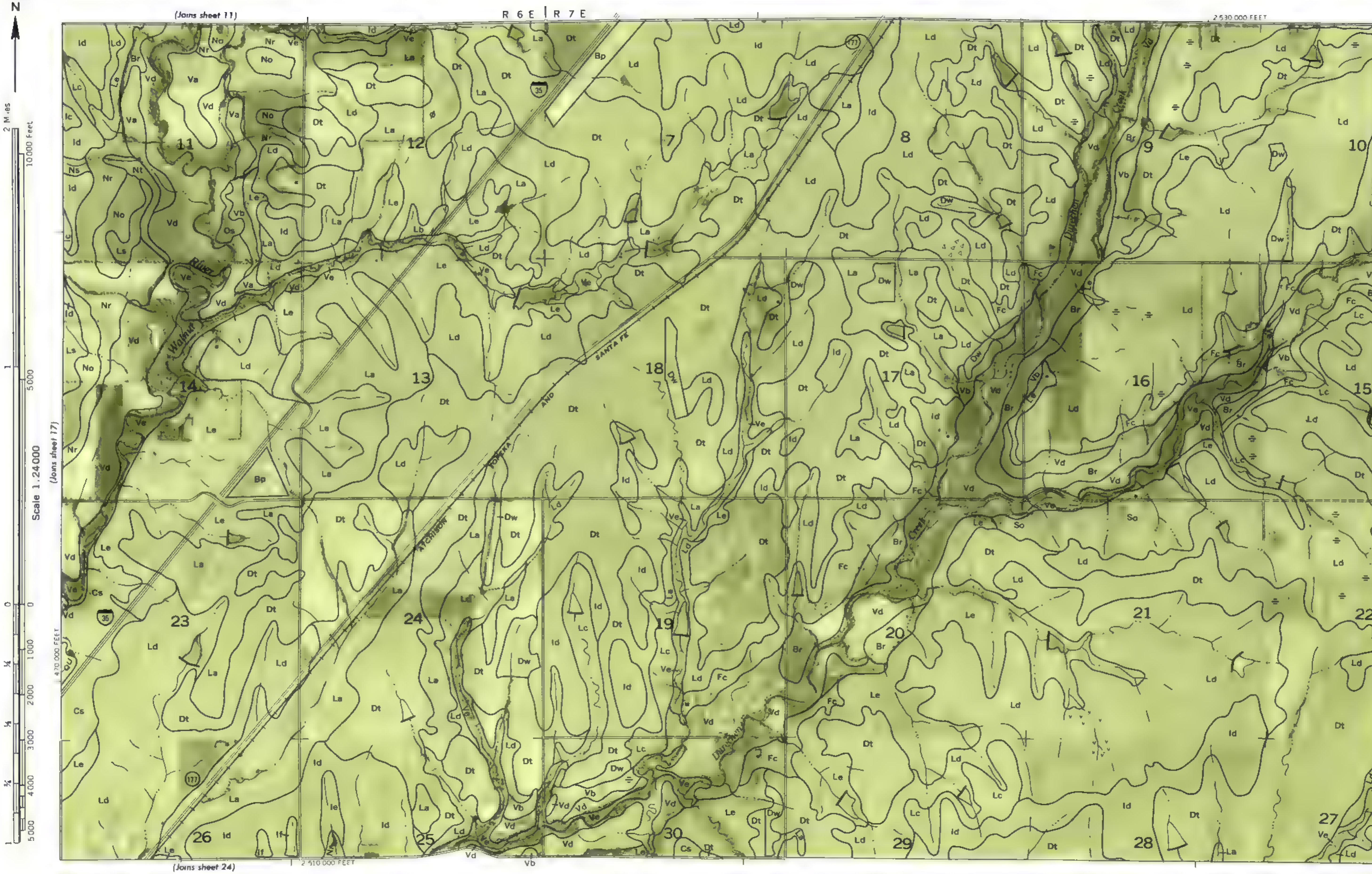
Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

BUTLER COUNTY, KANSAS NO. 16


(Joins sheet 10)
(Joins sheet 16)
(Joins sheet 18)
(Joins sheet 23)
R 5 E | R 6 E
T 24 S
N
Scale 1:24 000
LIMESTONE QUARRY
Cole Creek
Walnut
35
77

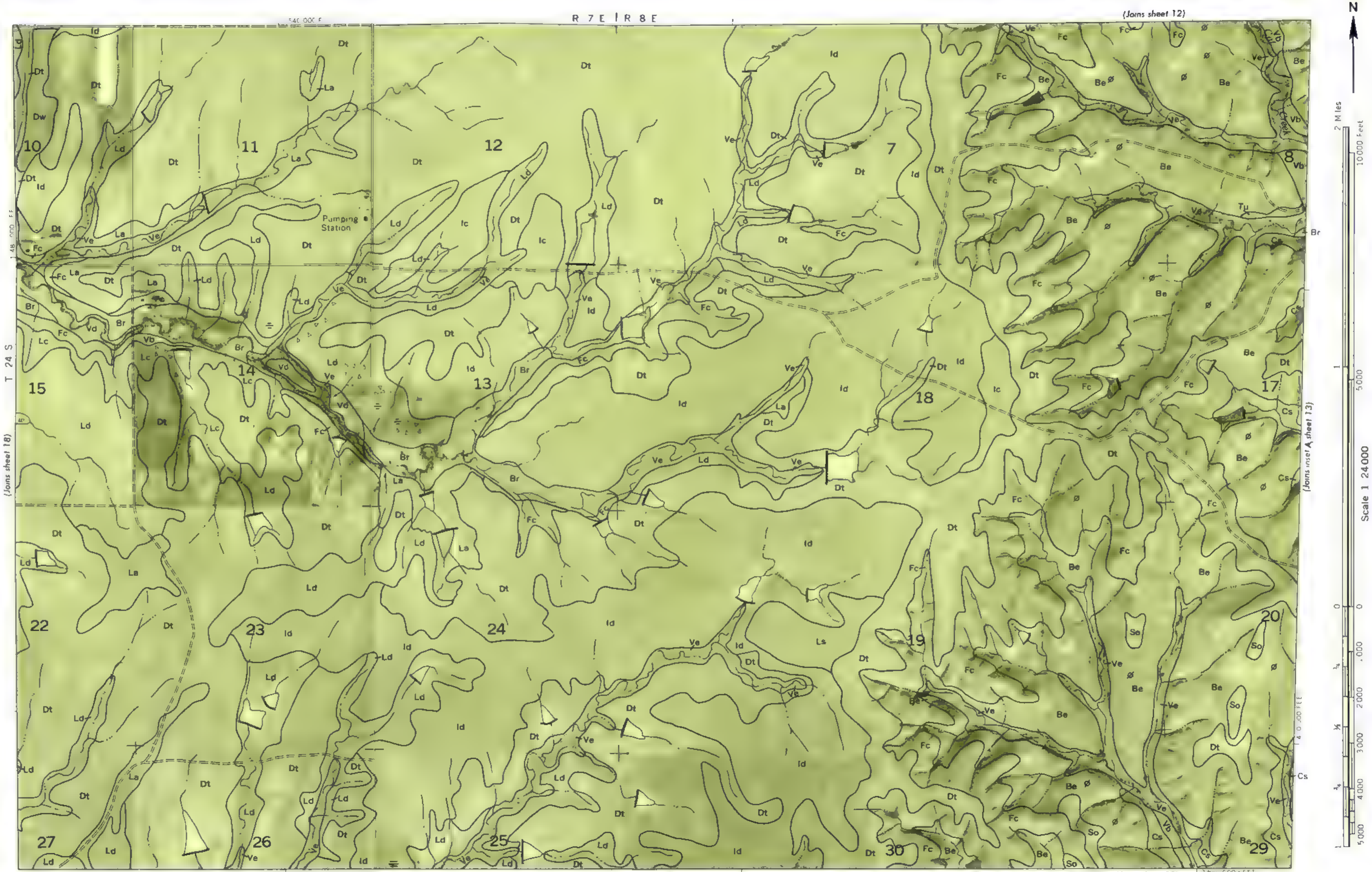
BUTLER COUNTY, KANSAS — SHEET NUMBER 18



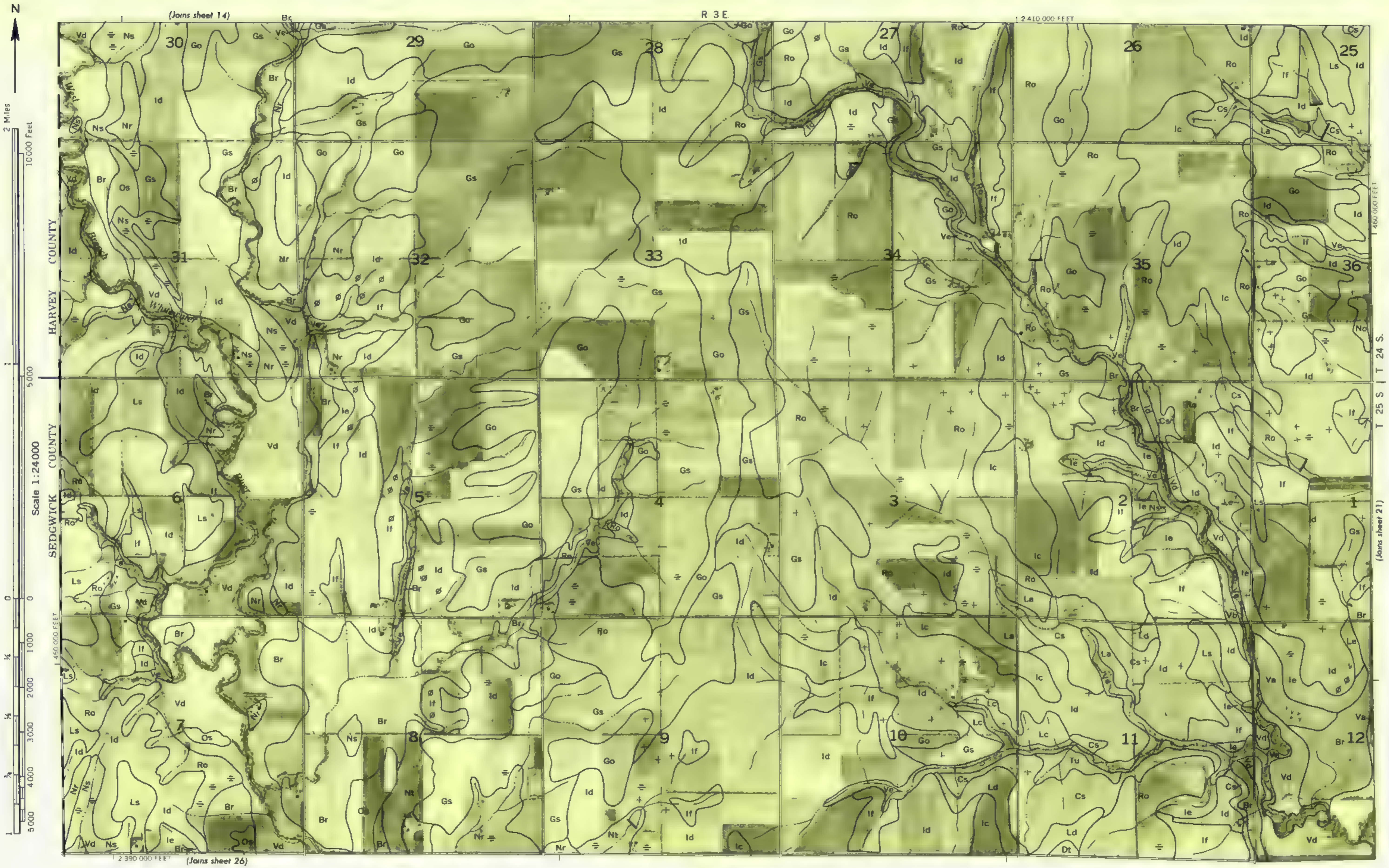
Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10 000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.



BUTLER COUNTY, KANSAS NO. 19

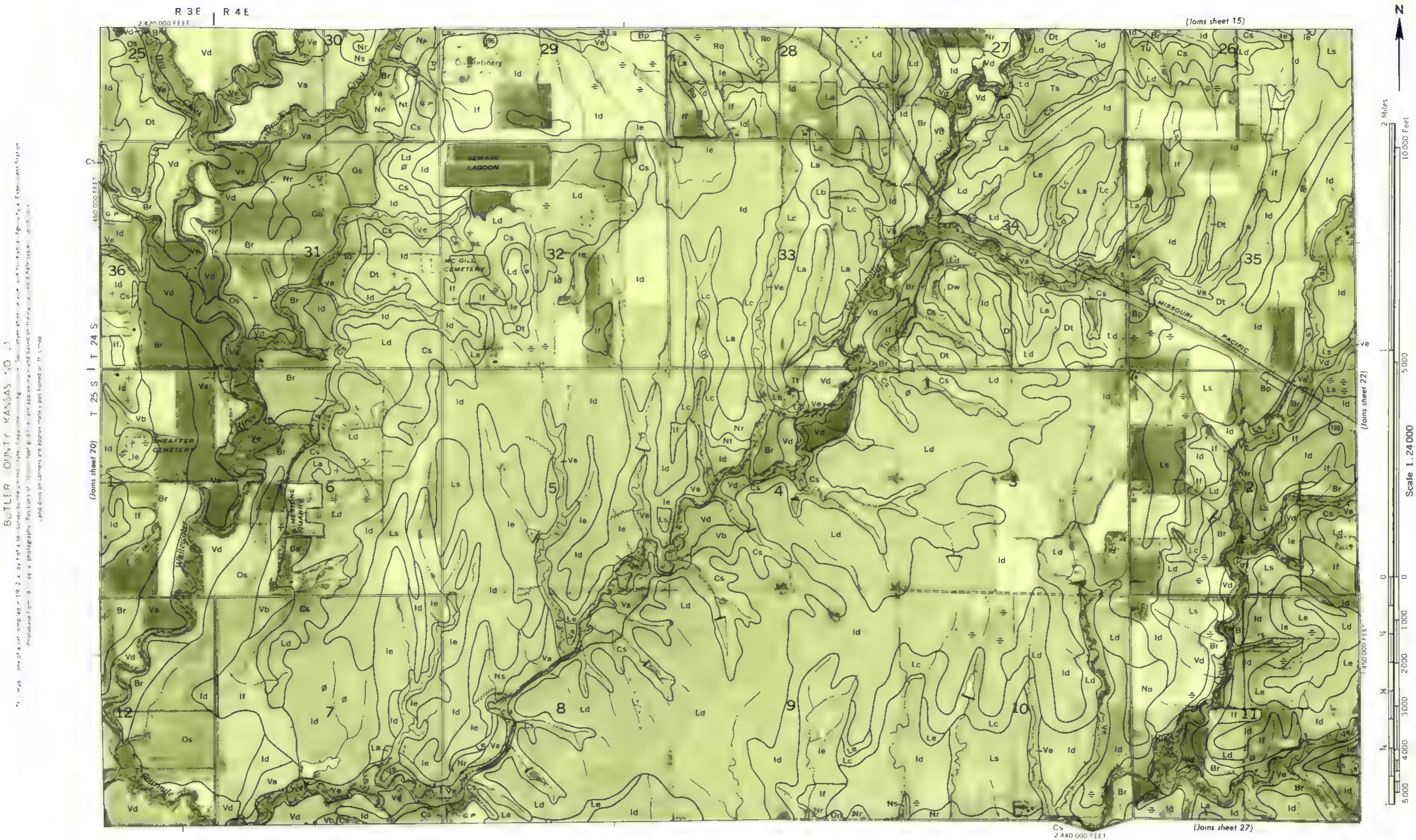


Land division corners are approximately positioned on this map

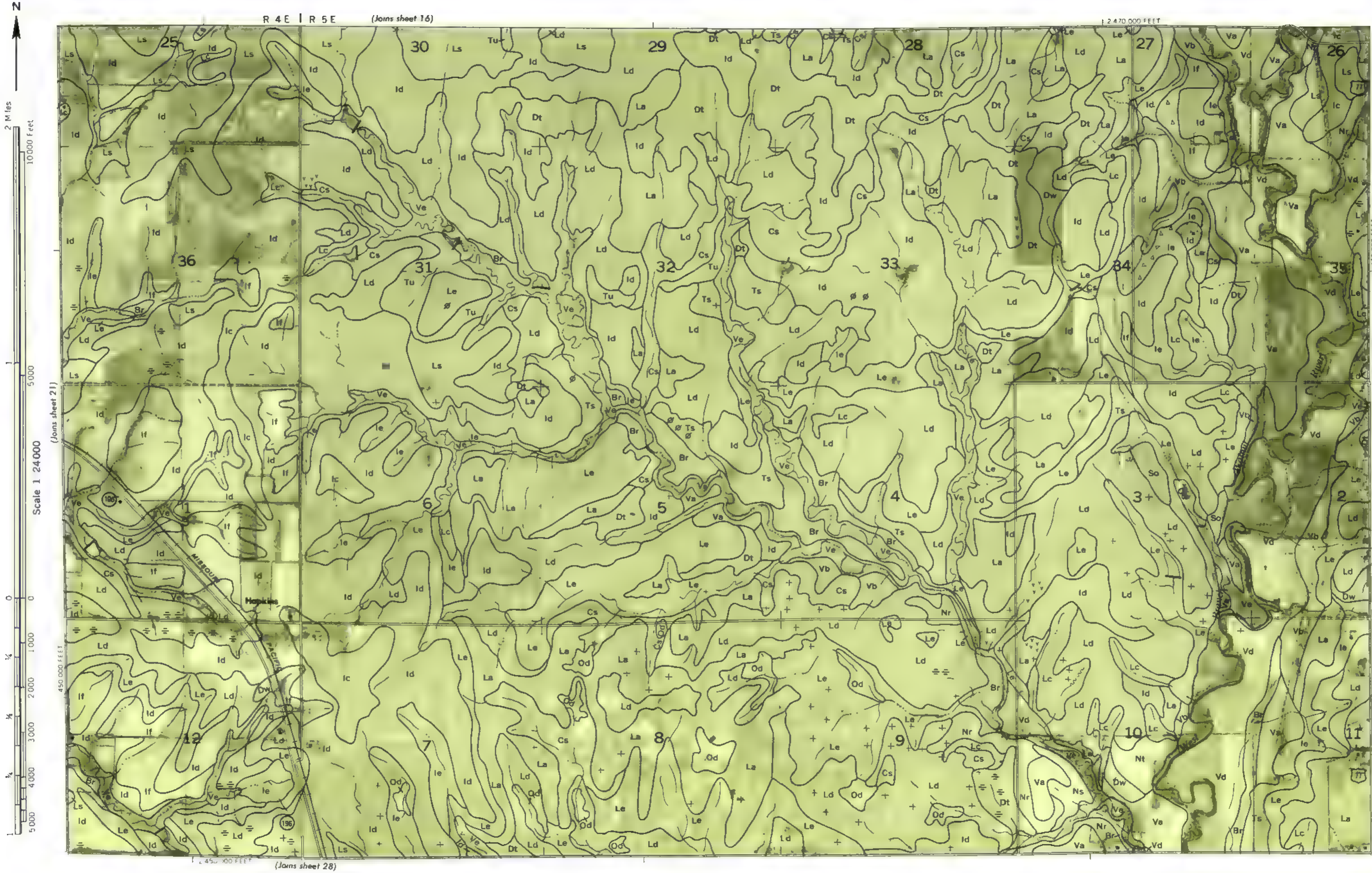
Photobase from 1970 aerial photography. Positions of [illegible] foot grid ticks are approximate and based on the Kansas coordinate system, south zone

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station

BUTLER COUNTY, KANSAS NO. 20


21
N
R 3 E
R 4 E
2 420 000 FEET
(Joins sheet 15)
(Joins sheet 20)
(Joins sheet 22)
(Joins sheet 27)
2 440 000 FEET
460 000 FEET
450 000 FEET
T 24 S
T 25 S
Oil Refinery
SEWAGE LAGOON
MC GILL CEMETERY
SHEAFFER CEMETERY
LIMESTONE QUARRY
MISSOURI PACIFIC
Whitewater River
Fourmile Creek
196
Scale 1:24 000
2 Miles
10 000 Feet
5000
1
0
1000
2000
3000
4000
5000
BUTLER COUNTY, KANSAS NO. 21

BUTLER COUNTY, KANSAS — SHEET NUMBER 22



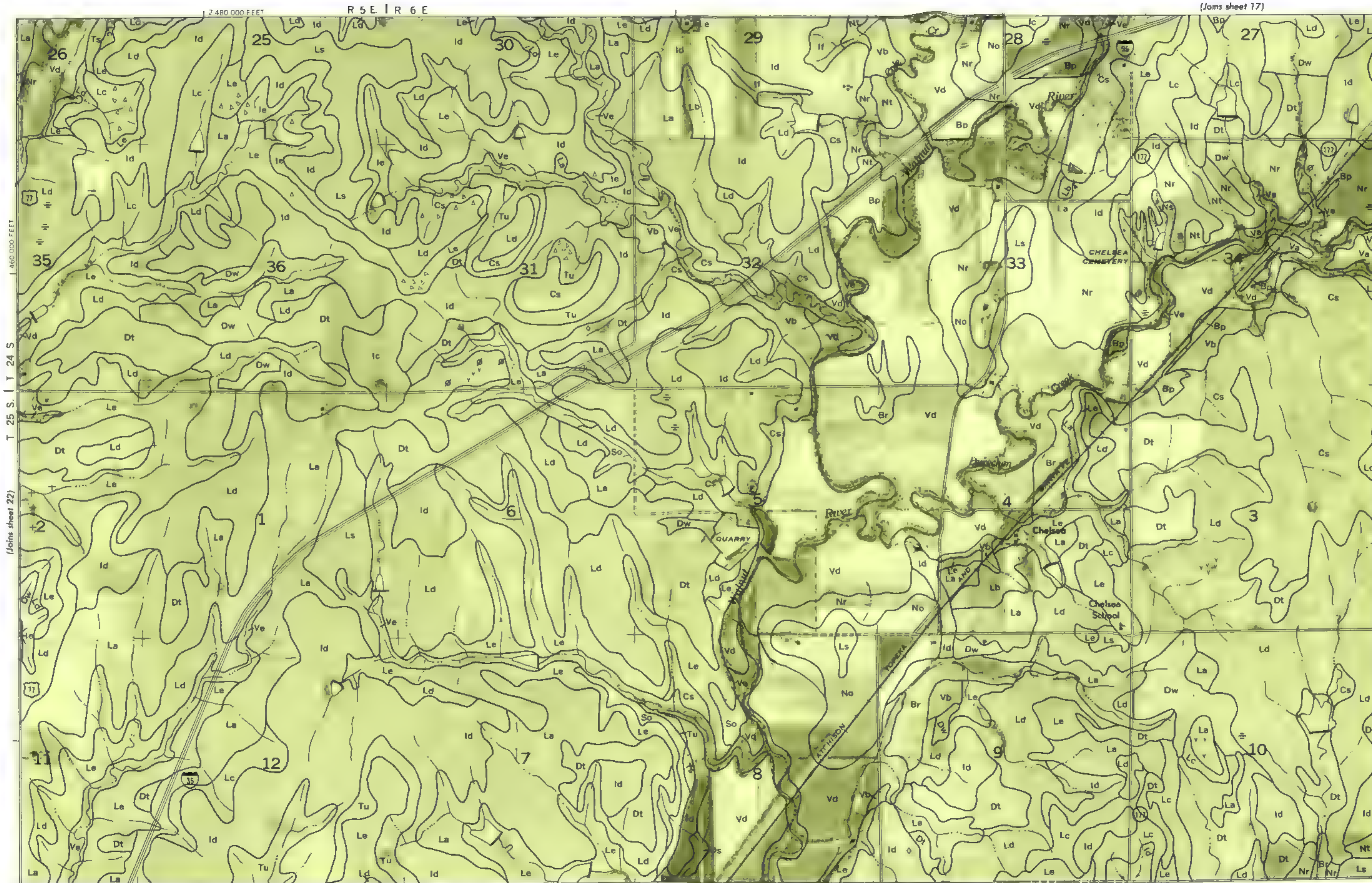
Land division corners are approximately positioned on this map

BUTLER COUNTY, KANSAS NO 23

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

Photobase from 1970 aerial photography. Positions of 10,000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

Land division corners are approximately positioned on this map.



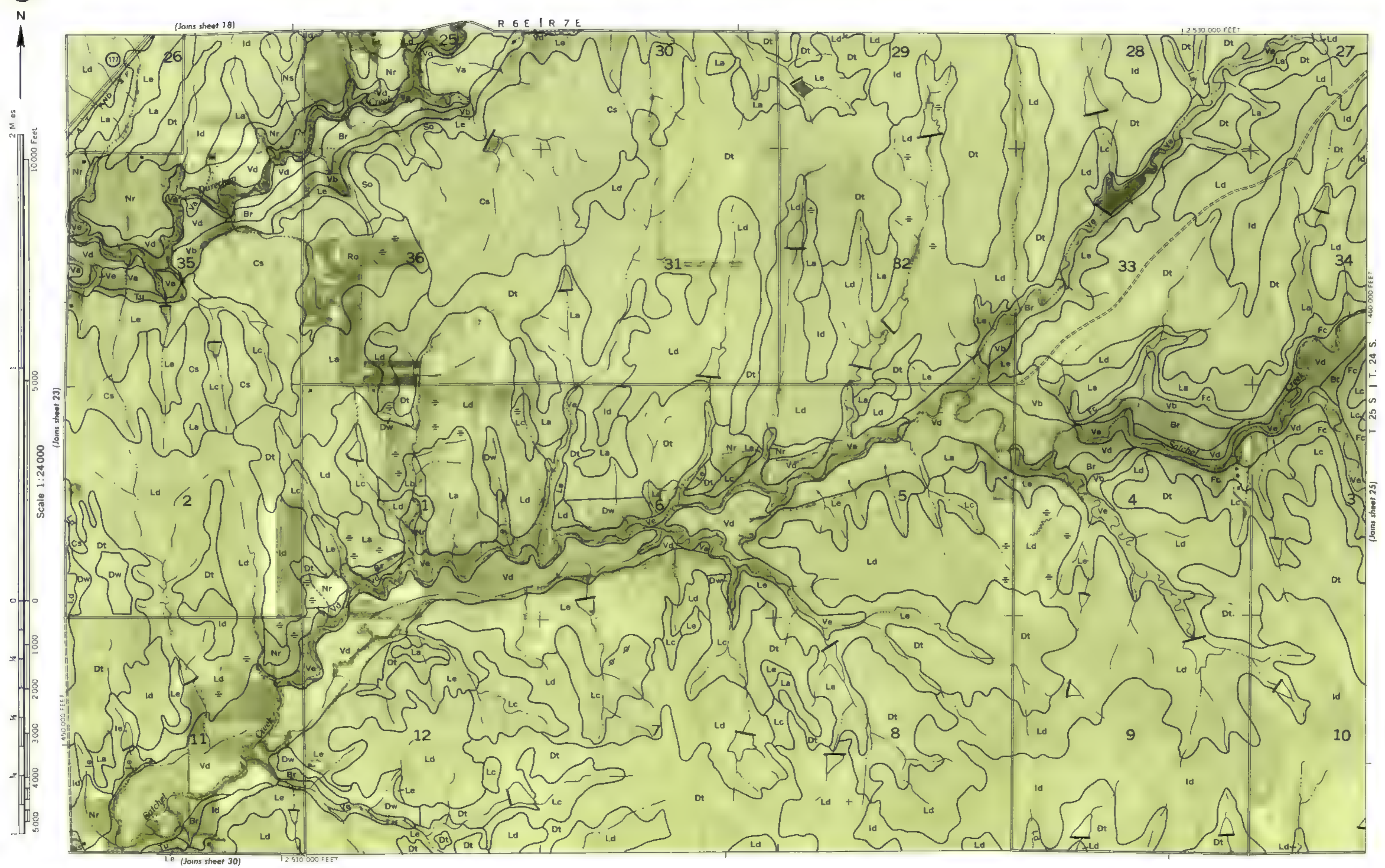
N

Scale 1:24000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

BUTLER COUNTY, KANSAS — SHEET NUMBER 24

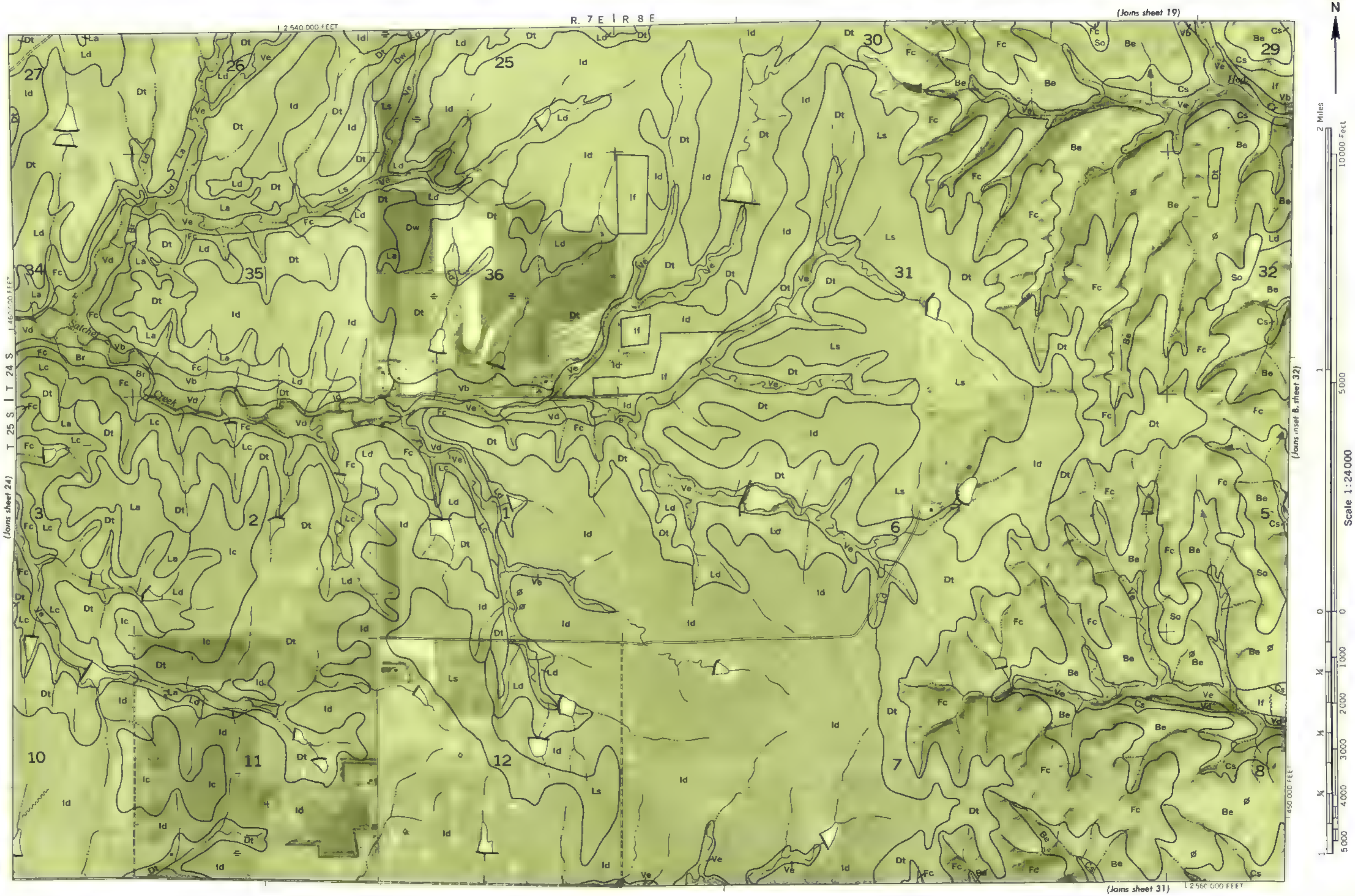


Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 10 000 foot grid ticks are approximate and based on the Kansas coordinate system south zone

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station

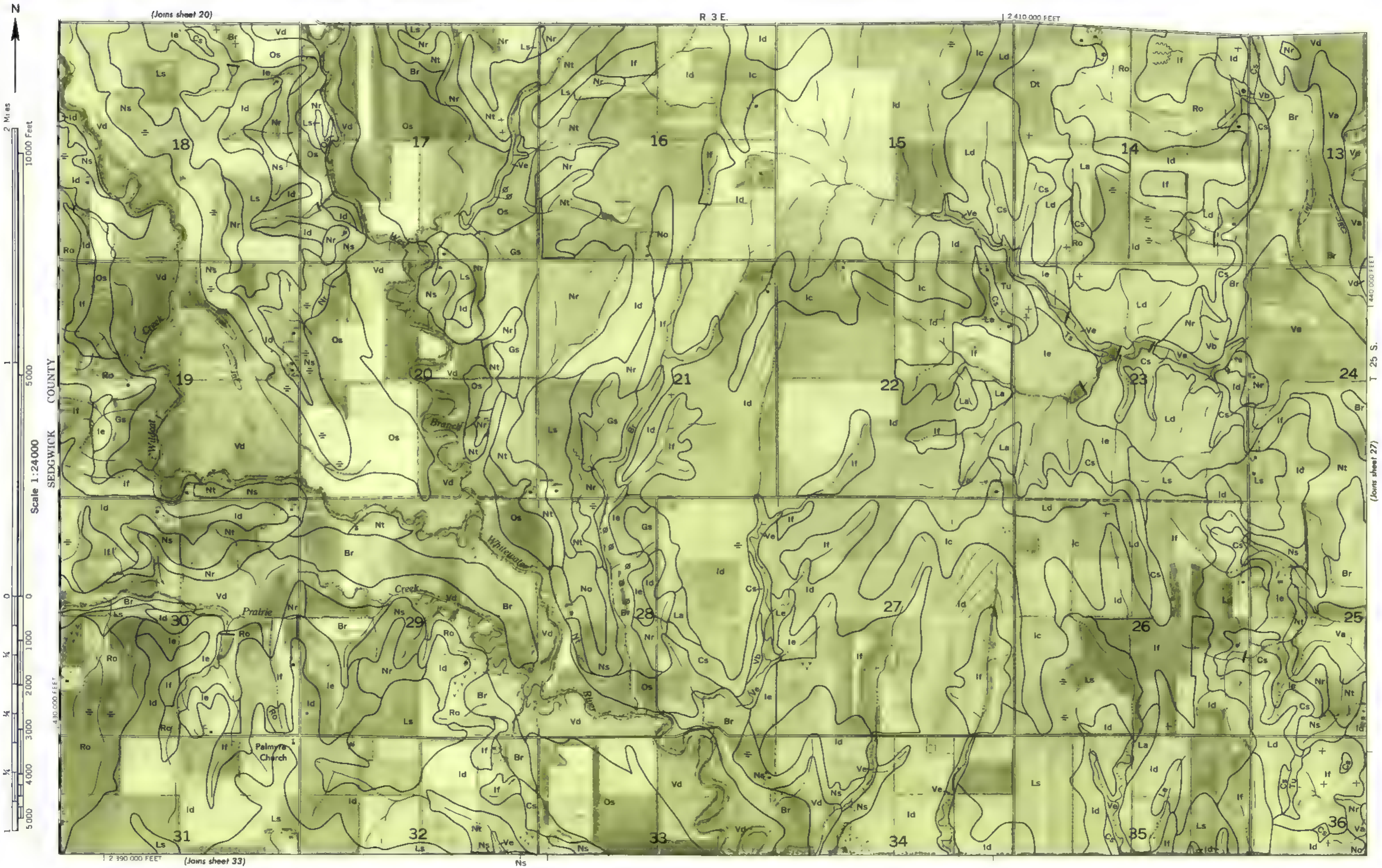
BUTLER COUNTY, KANSAS NO. 24



BUTLER COUNTY, KANSAS NO. 25

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 10 000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone.
Land division corners are approximately positioned on this map.

BUTLER COUNTY, KANSAS — SHEET NUMBER 26

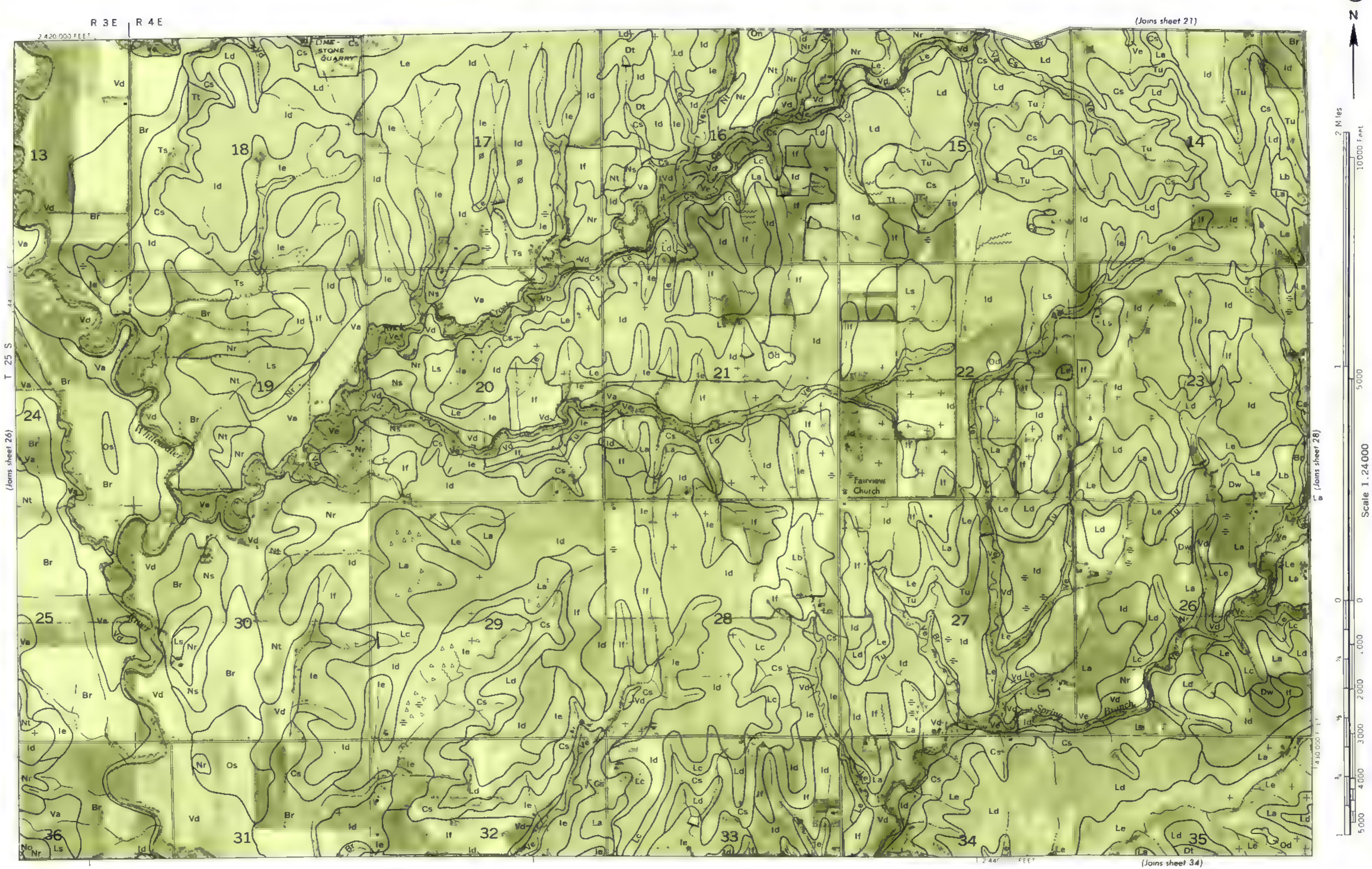


Land division corners are approximately positioned on this map

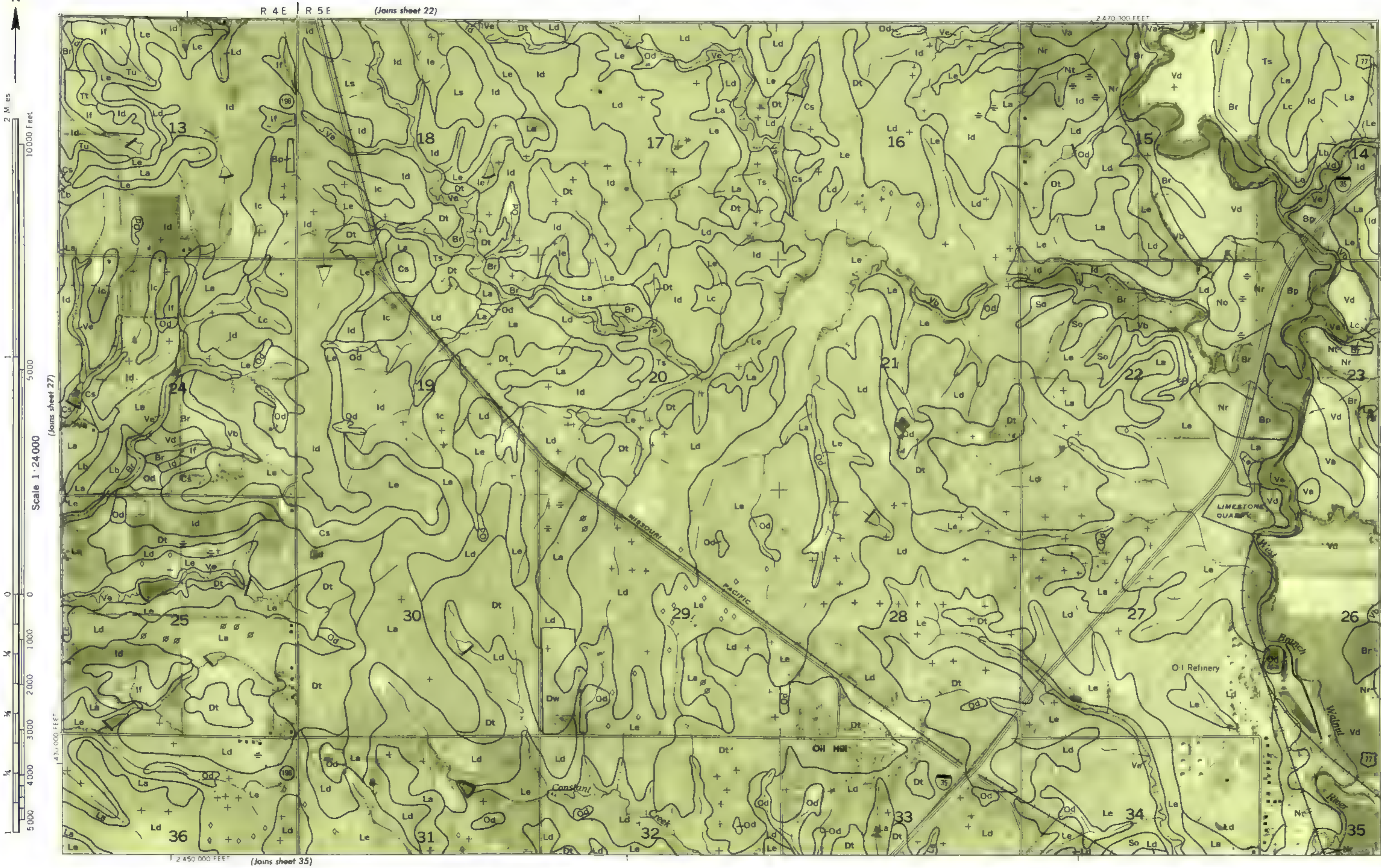
Photobase from 1970 aerial photography. Positions of 10 000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station

BUTLER COUNTY, KANSAS NO 26


27
N
R 3 E
R 4 E
T 25 S
(Joins sheet 21)
(Joins sheet 26)
(Joins sheet 28)
(Joins sheet 34)
LIME-STONE QUARRY
Fairview Church
Whitewater River
Spring Branch
Scale 1:24000
2 Miles
1
0
10000 Feet
5000
0
1000
2000
3000
4000
5000

BUTLER COUNTY, KANSAS — SHEET NUMBER 28

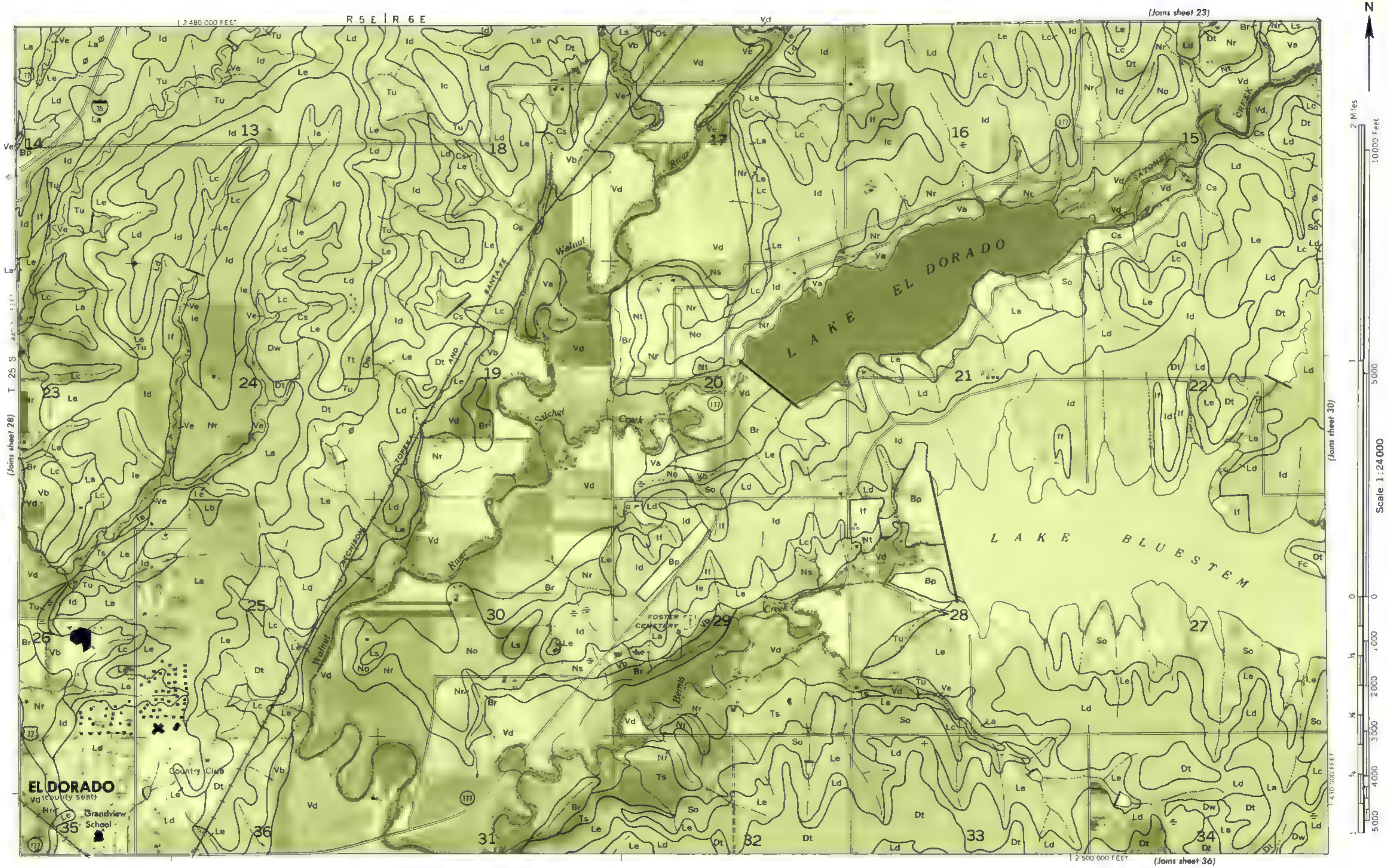


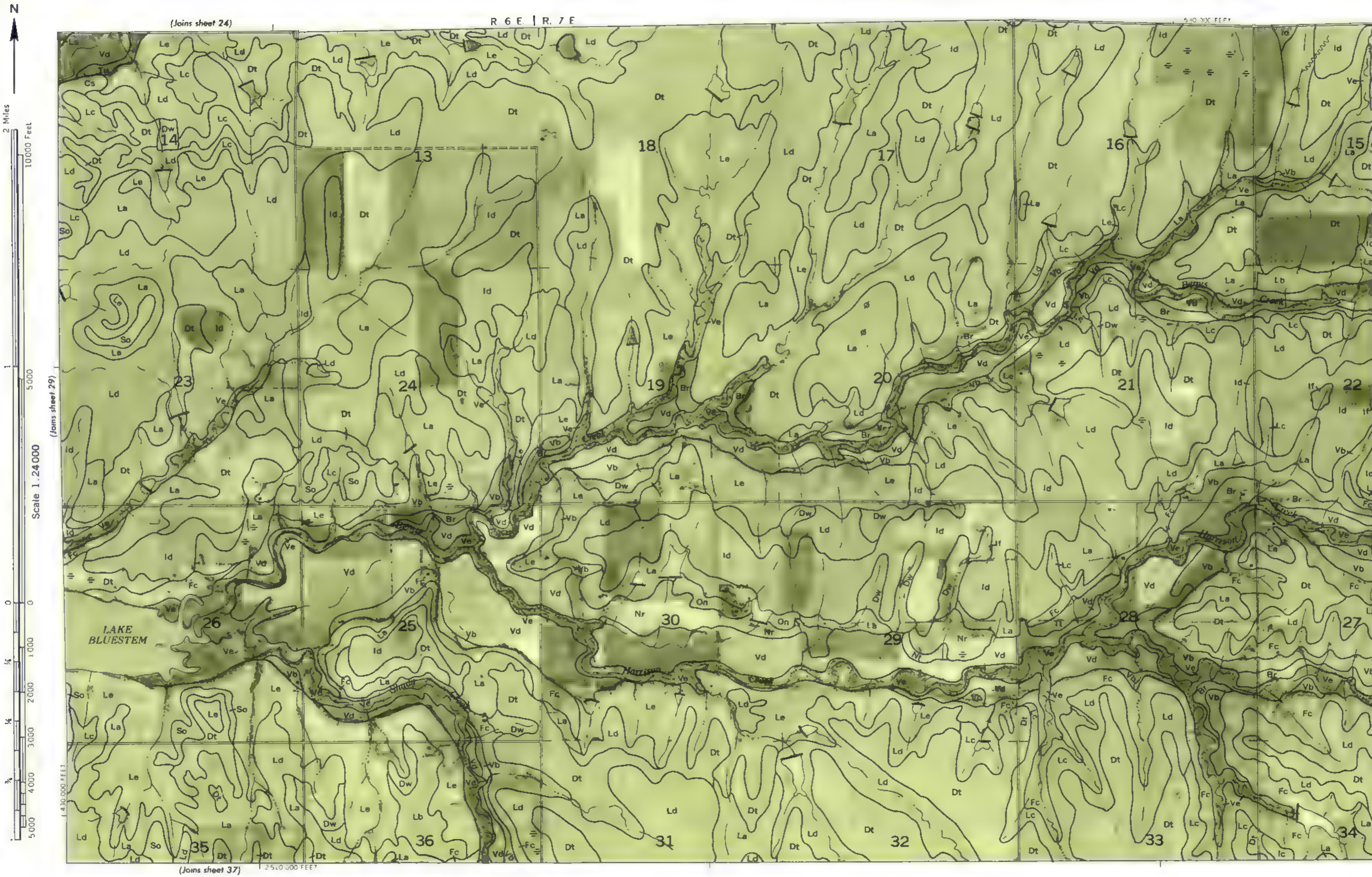
Land division corners are approximately positioned on this map

29

BUTLER COUNTY, KANSAS NO. 29

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.
Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.
Land division corners are approximately positioned on this map.





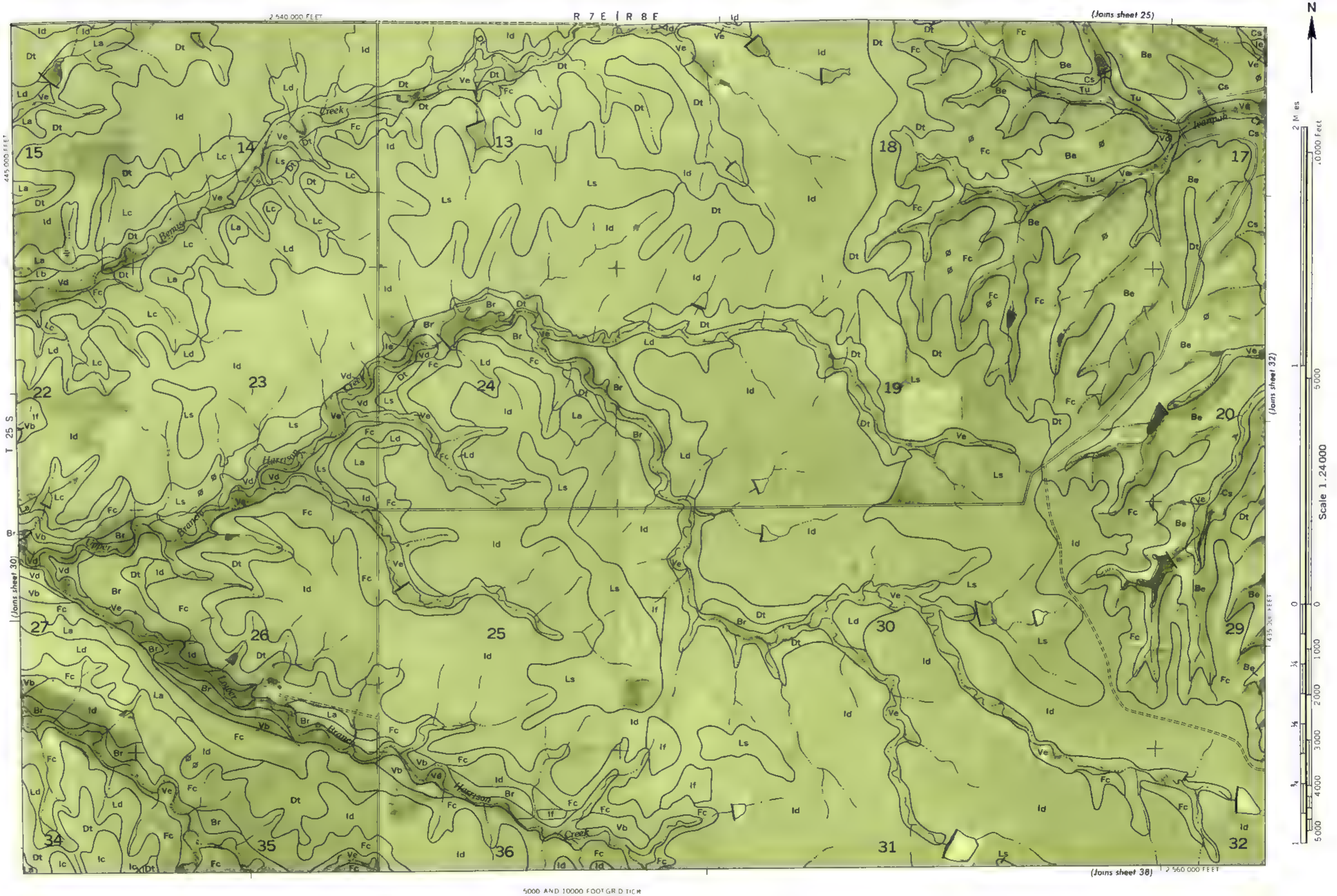
Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10,000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

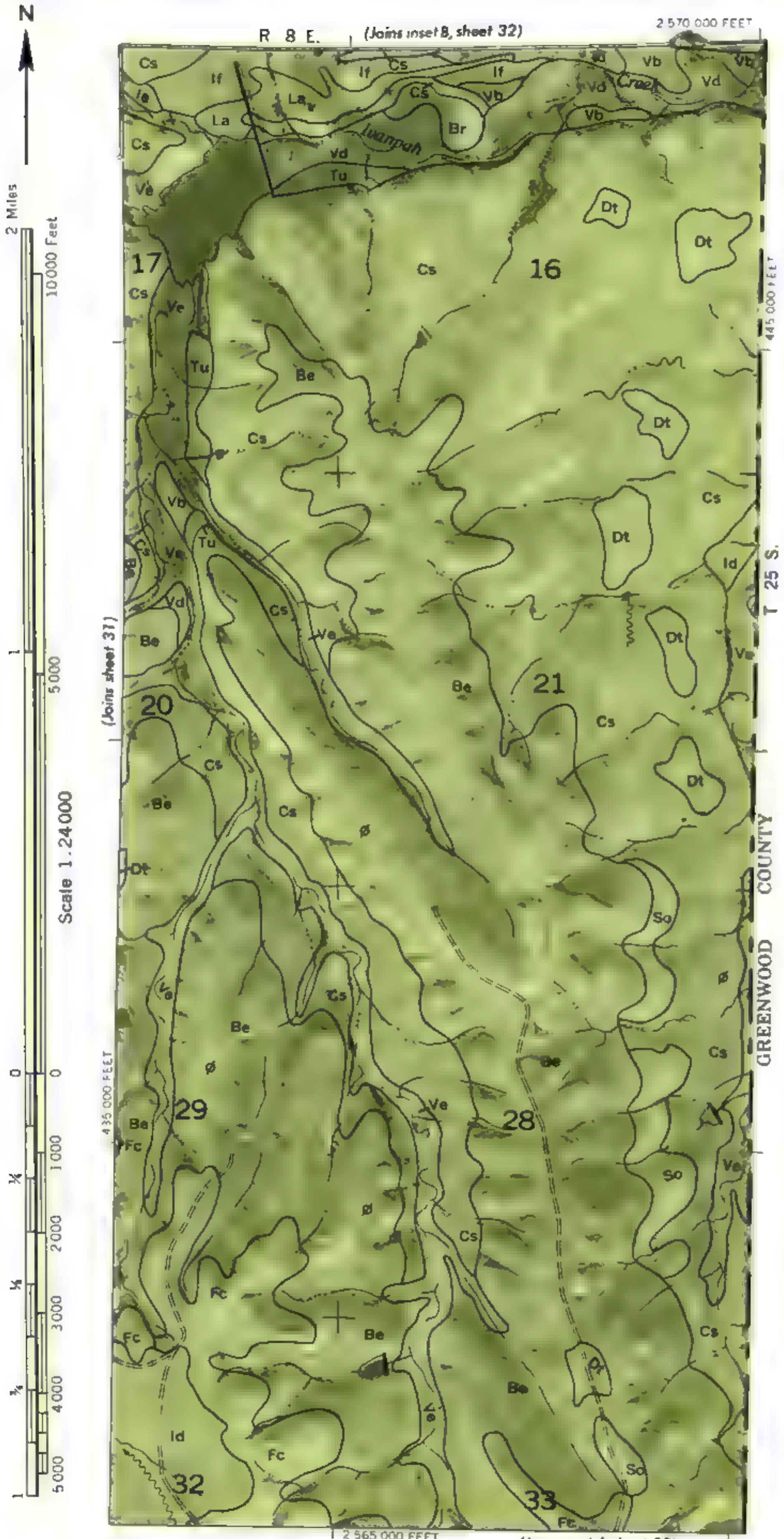
BUTLER COUNTY, KANSAS NO. 30

(31)



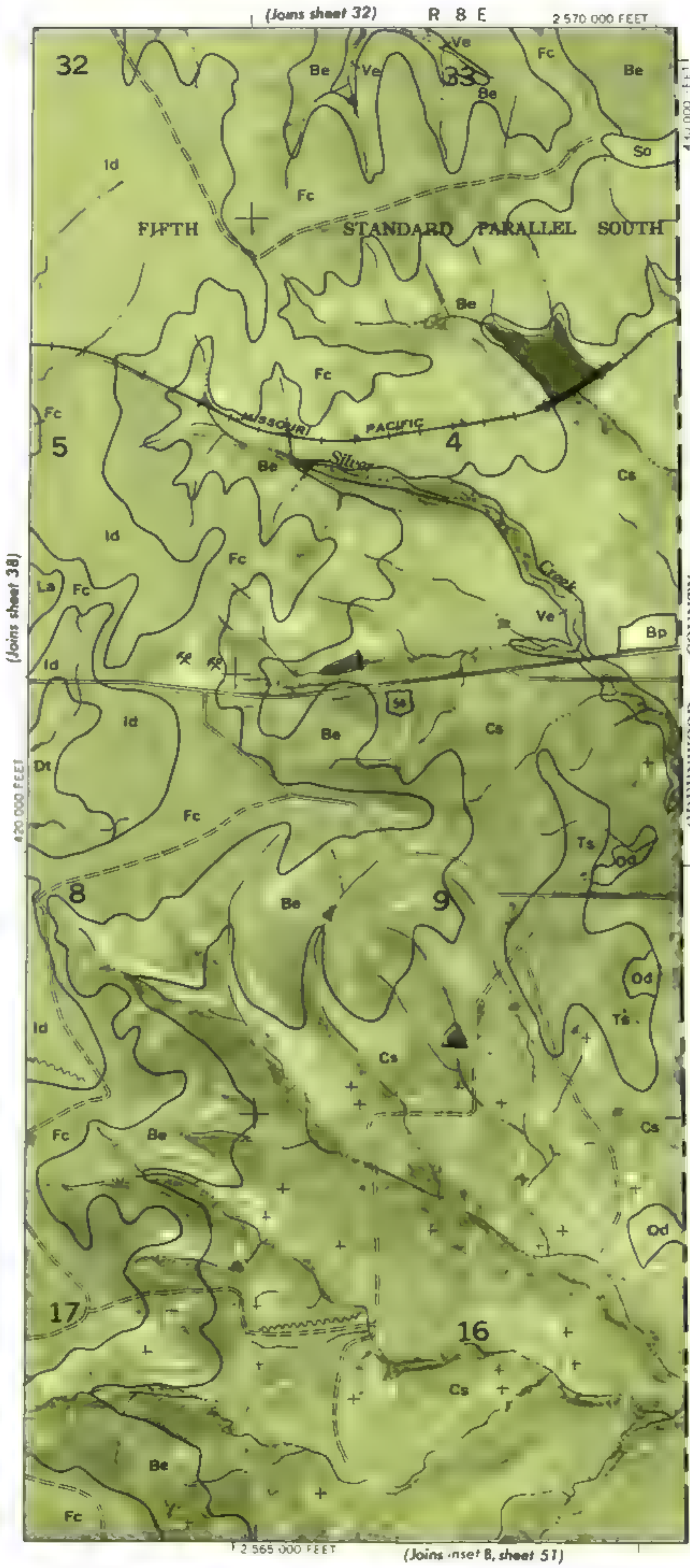
BUTLER COUNTY, KANSAS NO. 31

BUTLER COUNTY, KANSAS — SHEET NUMBER 32



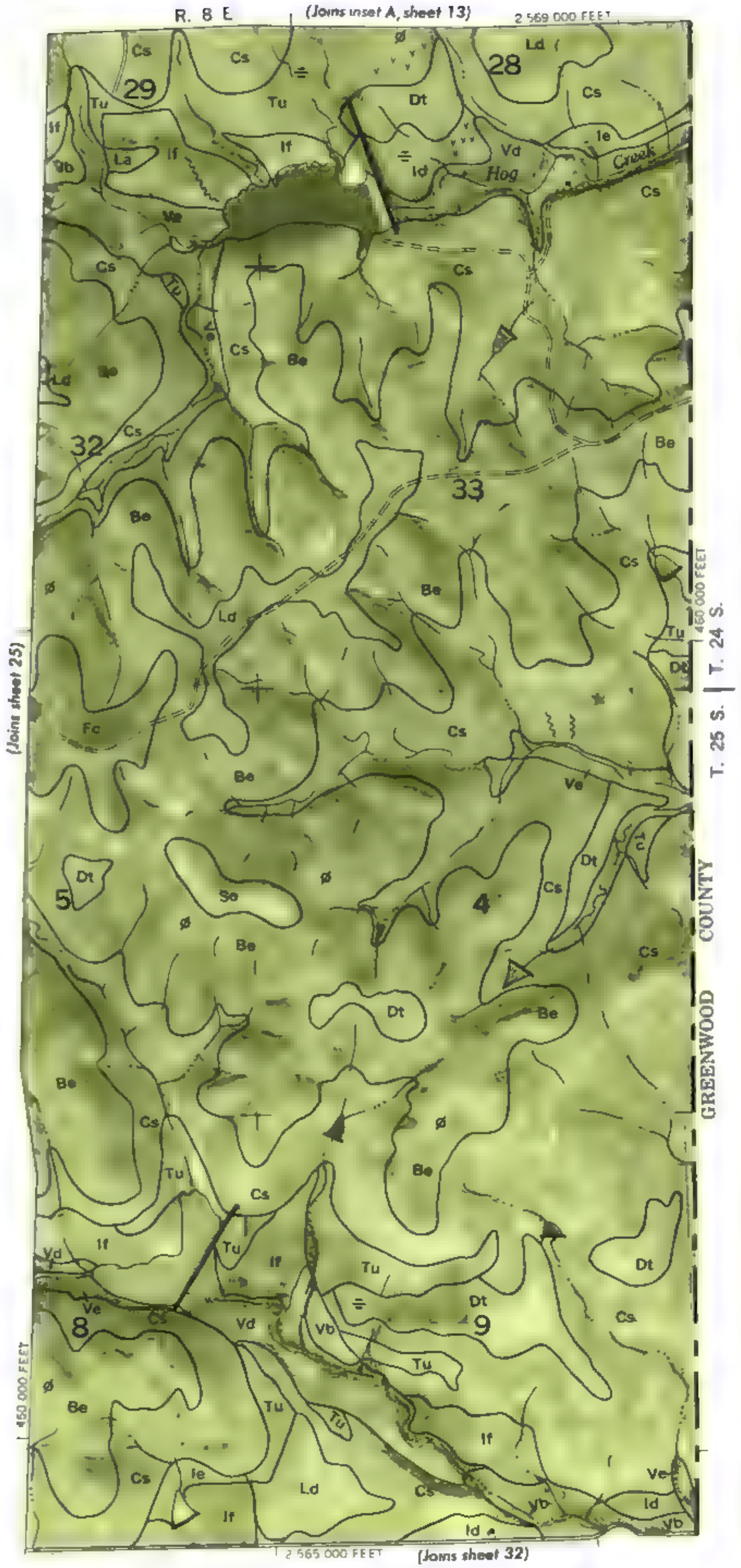
5000-FOOT GRID TICKS

INSET A



5000 AND 10000-FOOT GRID TICKS

INSET B



4000 AND 10000-FOOT GRID TICKS

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

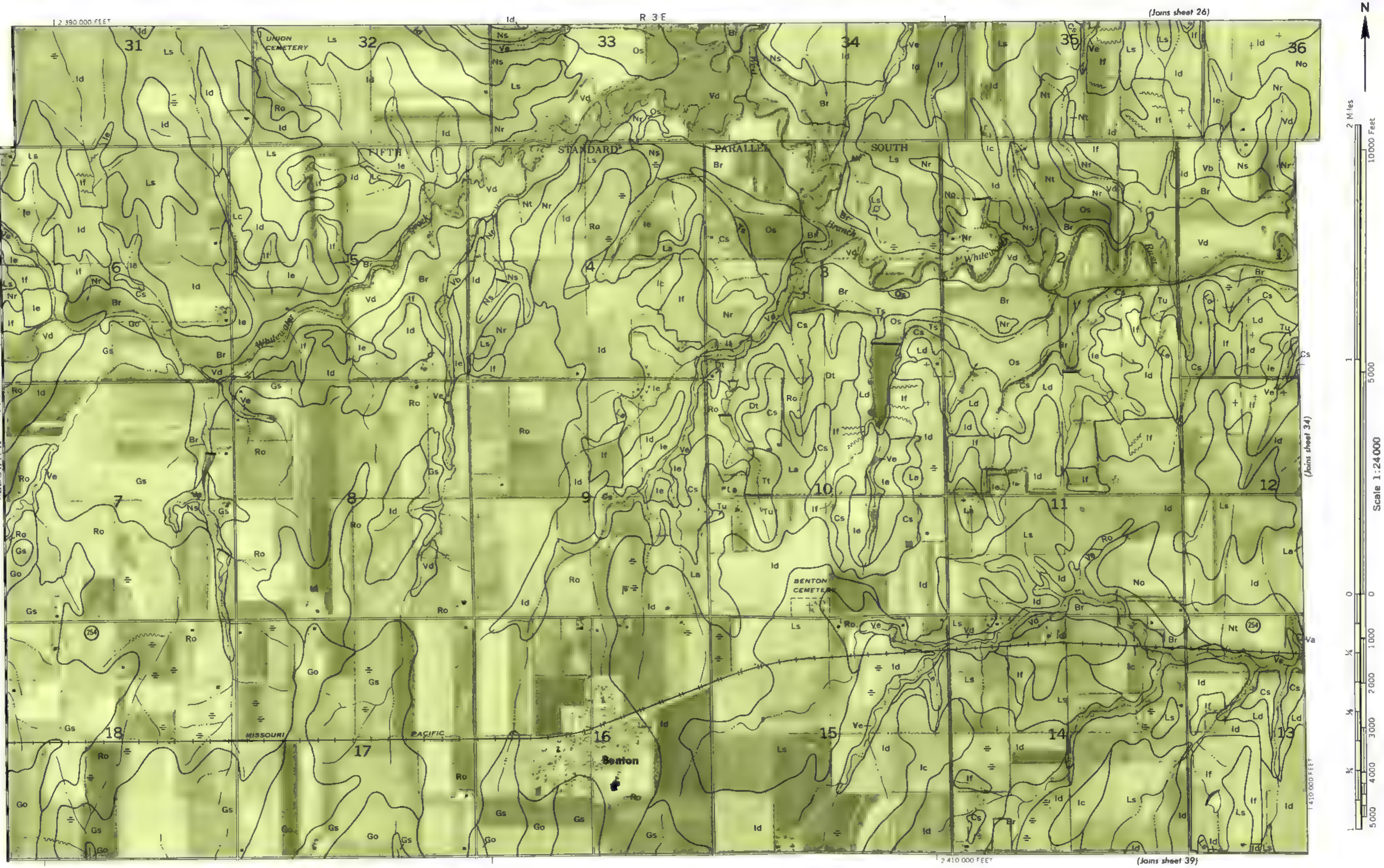
BUTLER COUNTY, KANSAS NO. 32

BUTLER COUNTY, KANSAS NO 33

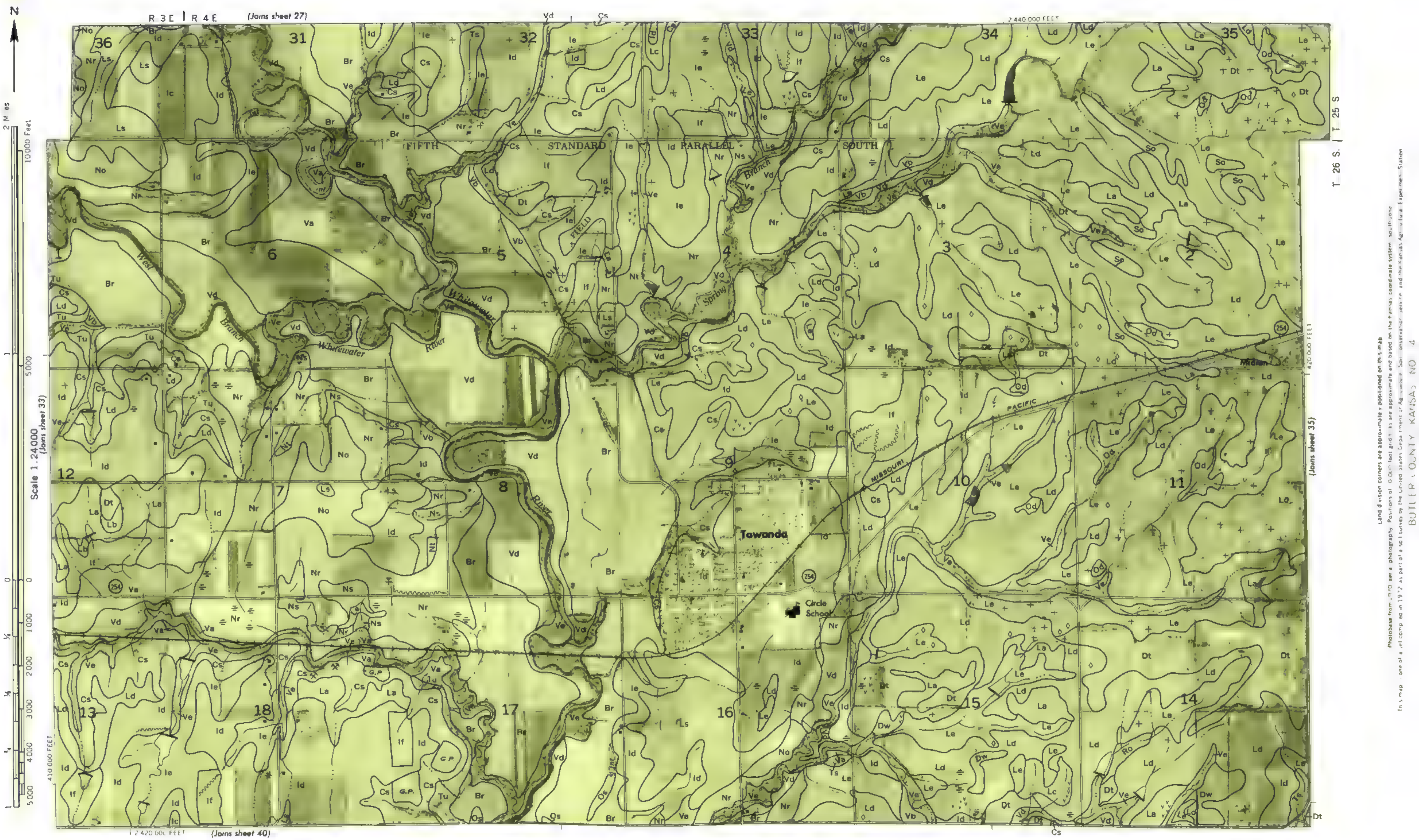
This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

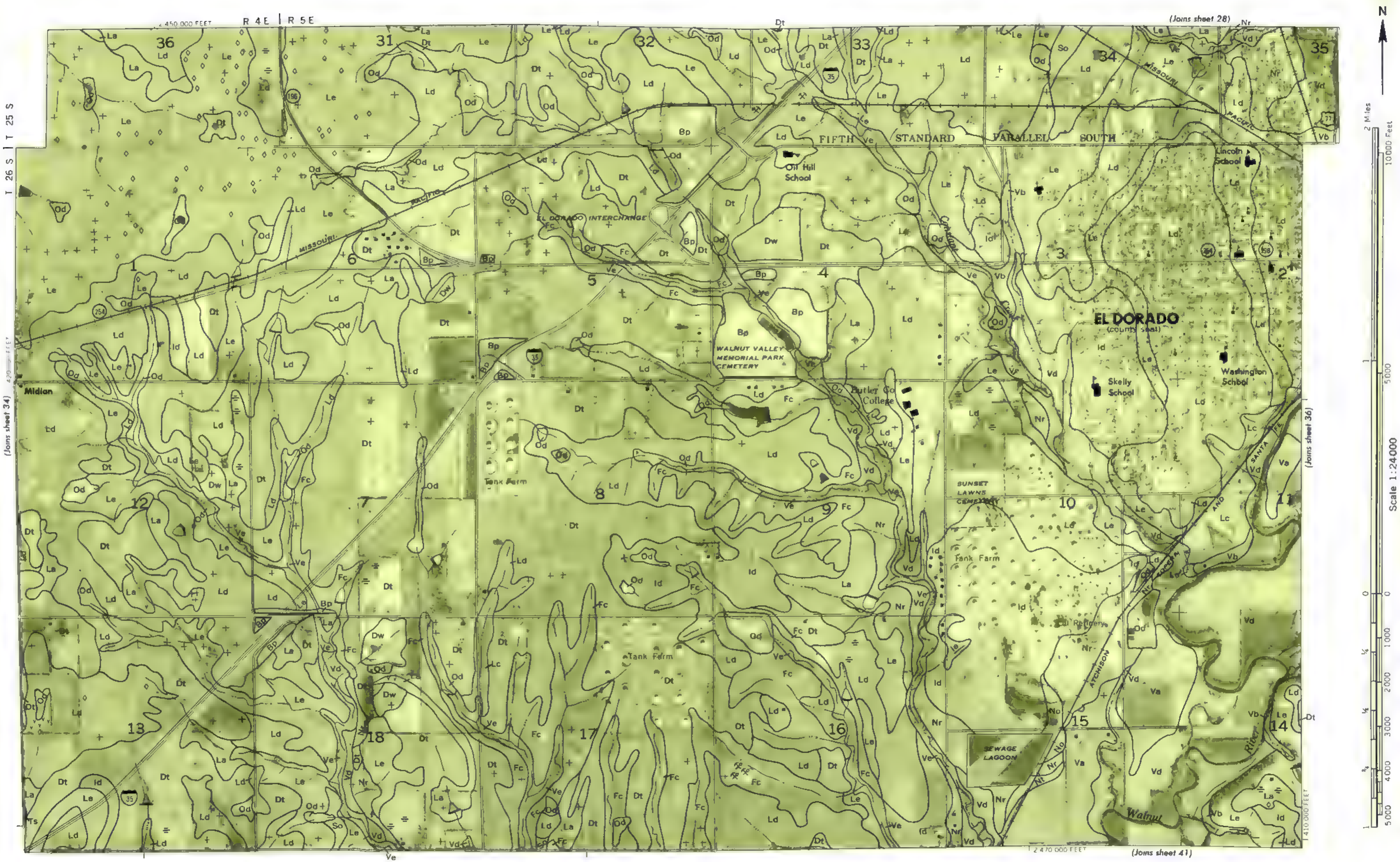
Photobase from 1970 aerial photography. Positions of 10,000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

Land division corners are approximately positioned on this map.

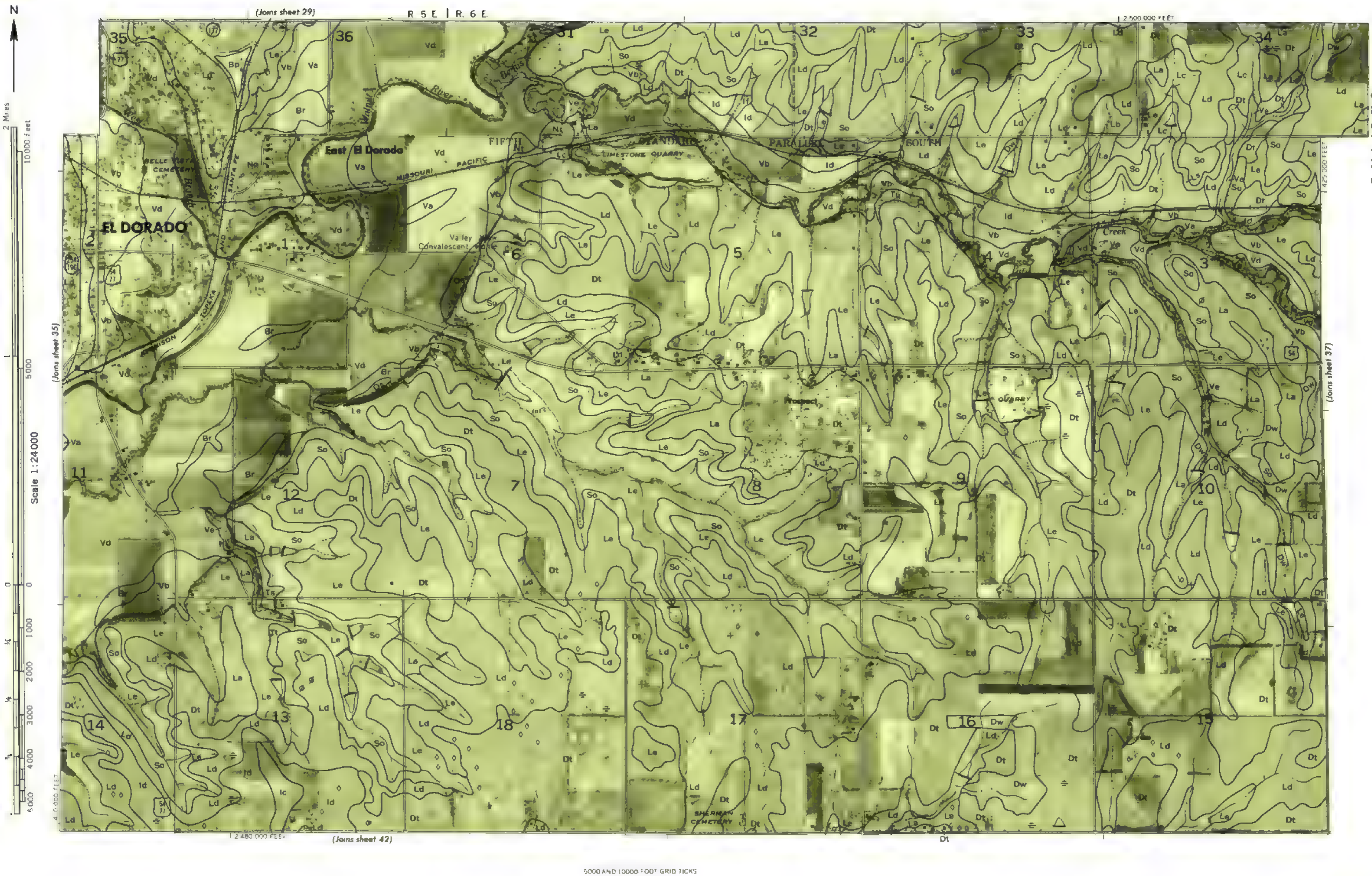


BUTLER COUNTY, KANSAS — SHEET NUMBER 34




35
N
R 4 E
R 5 E
450 000 FEET
(Joins sheet 28)
(Joins sheet 34)
(Joins sheet 36)
(Joins sheet 41)
2 470 000 FEET
410 000 FEET
T 25 S
T 26 S
FIFTH STANDARD PARALLEL SOUTH
MISSOURI PACIFIC
ATCHISON TOPEKA AND SANTA FE
EL DORADO
(county seat)
EL DORADO INTERCHANGE
Oil Hill School
Lincoln School
Washington School
Skelly School
Butler Co College
WALNUT VALLEY MEMORIAL PARK CEMETERY
SUNSET LAWNS CEMETERY
Tank Farm
Refinery
SEWAGE LAGOON
Midian
Walnut River
Scale 1:24 000
2 Miles
10000 Feet

BUTLER COUNTY, KANSAS — SHEET NUMBER 36



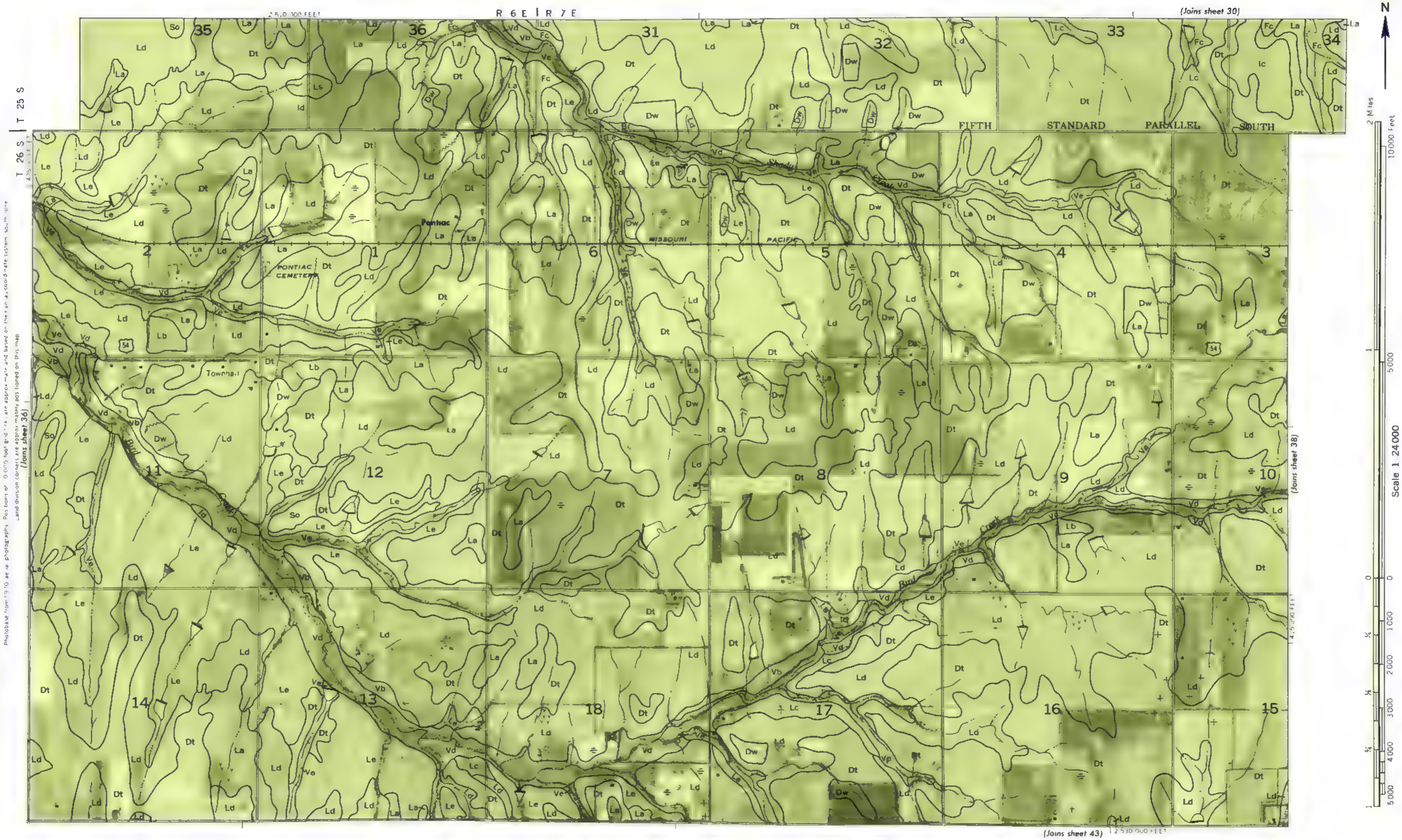
Land division corners are approximately positioned on this map.

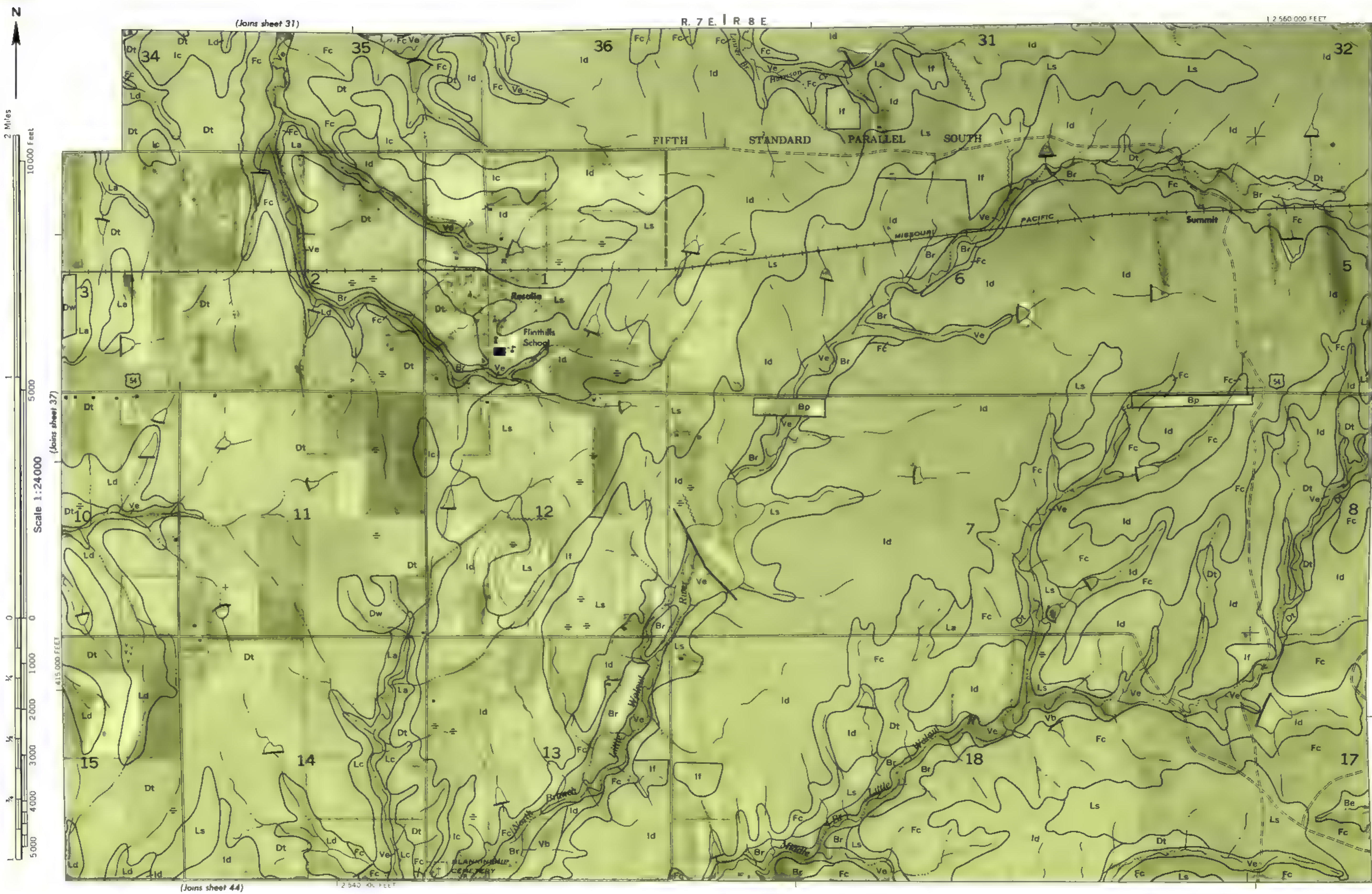
Photobase from 1970 aerial photography. Positions of 5 000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

BUTLER COUNTY, KANSAS NO. 36

BUTLER COUNTY, KANSAS — SHEET NUMBER 37



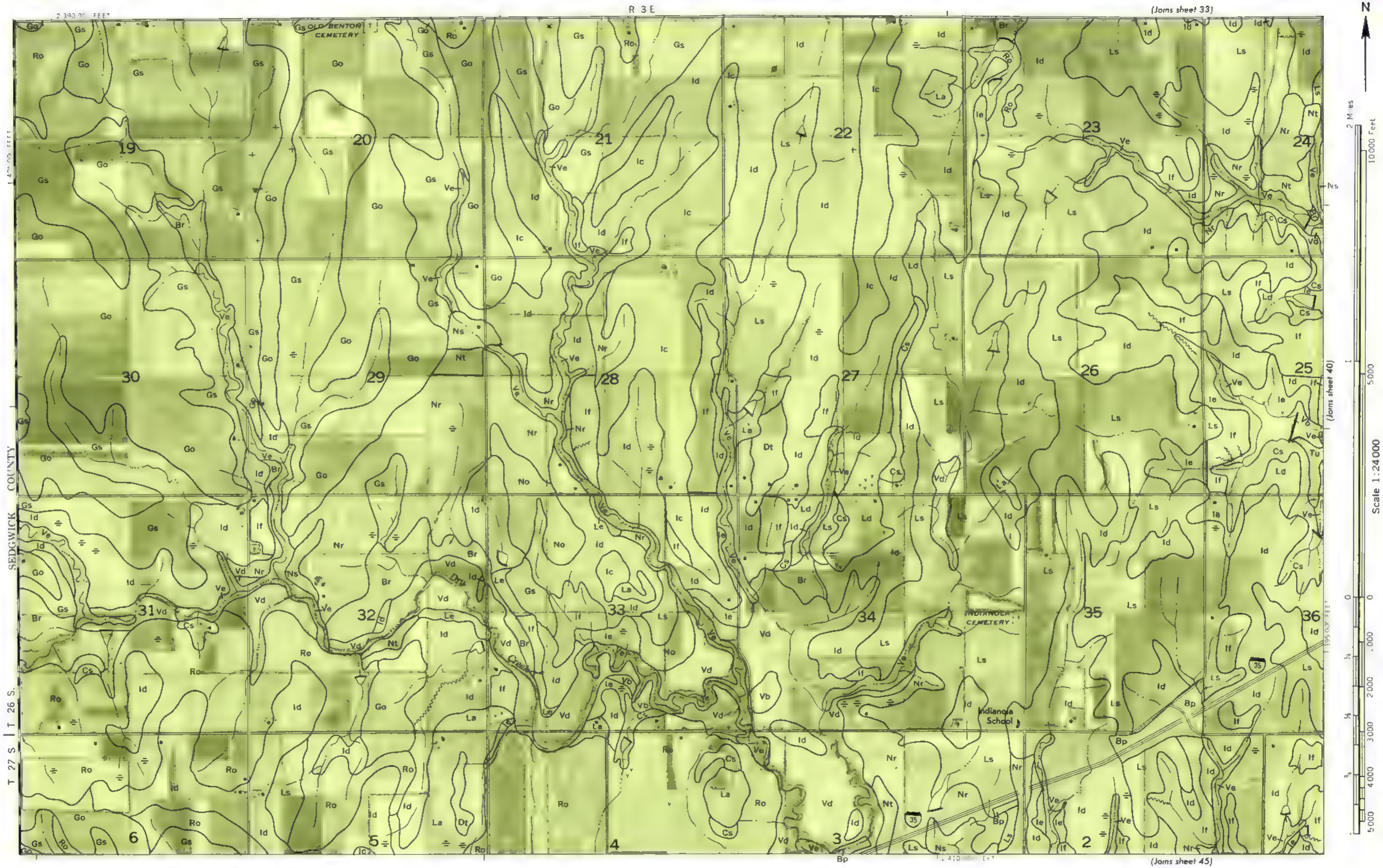


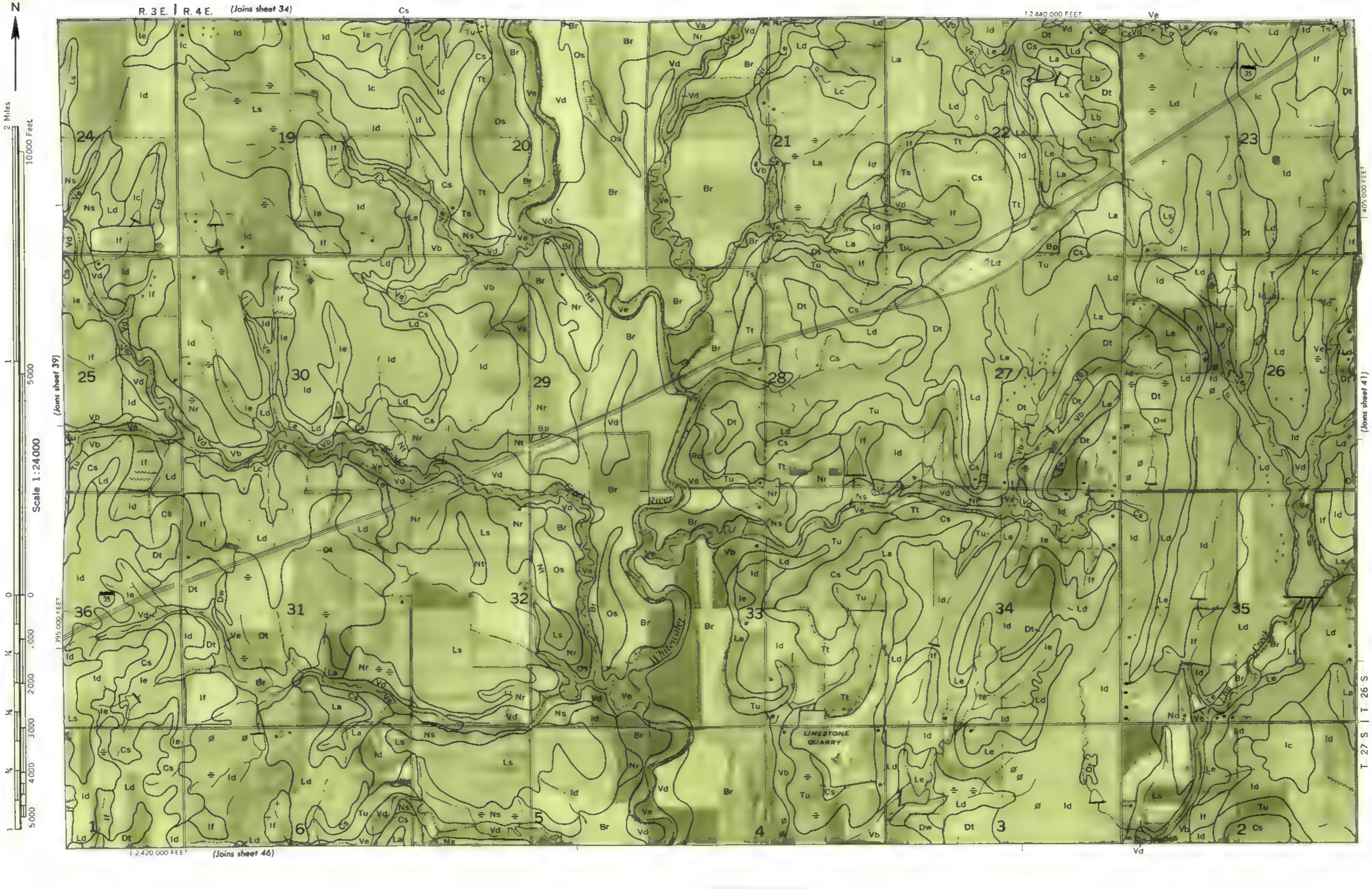
5000 AND 10000 FOOT GRID TICKS

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10 000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.


R 3 E
(Joins sheet 33)
(Joins sheet 40)
(Joins sheet 45)
N
OLD BENTON CEMETERY
INDIANOLA CEMETERY
Indianola School
Dry Creek
SEDGWICK COUNTY
T 26 S.
T 27 S
Scale 1:24 000
10000 Feet
2 Miles
19
20
21
22
23
24
30
29
28
27
26
25
31
32
33
34
35
36
6
5
4
3
2
1



Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

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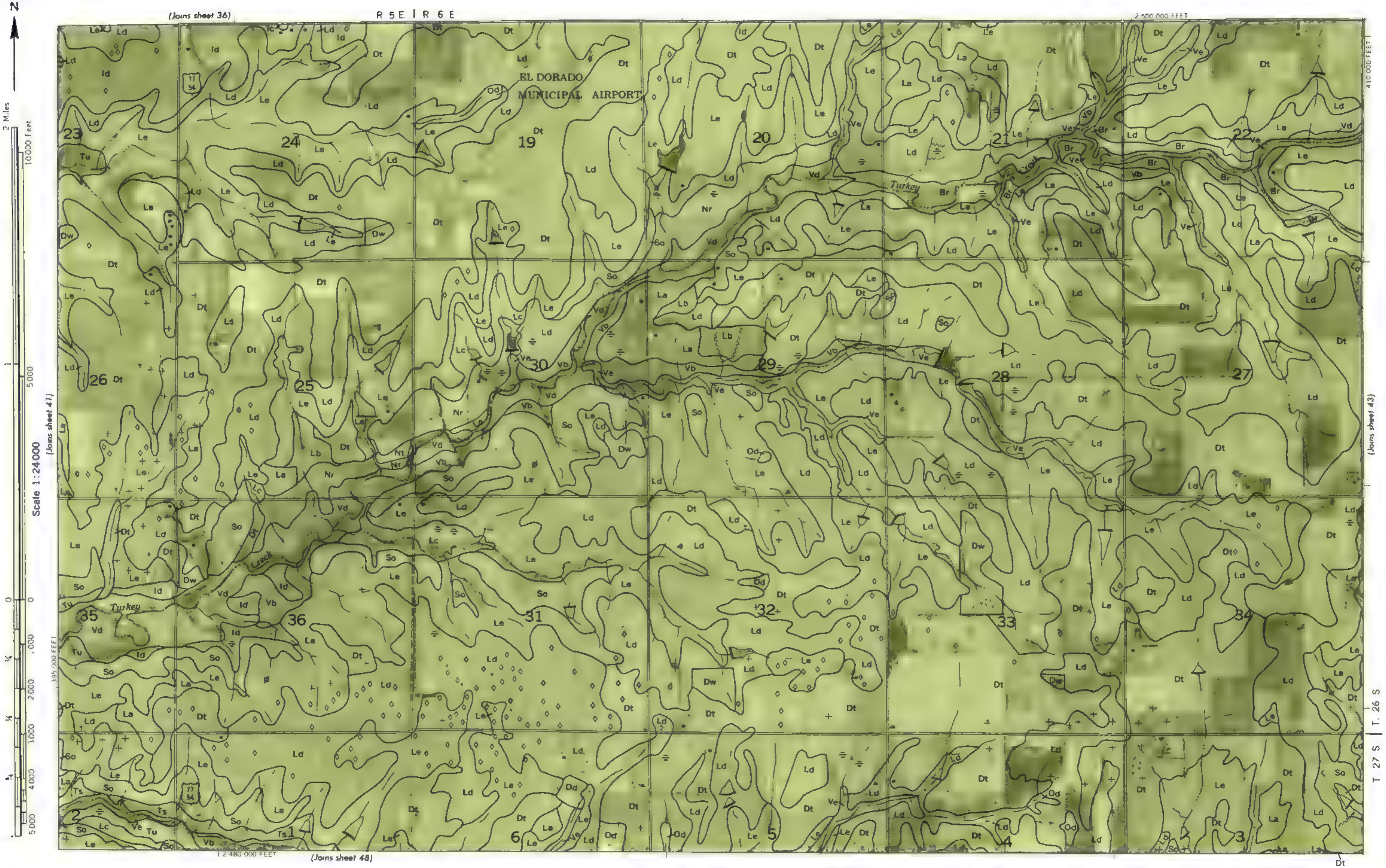
BUTLER COUNTY, KANSAS NO. 40

Land division corners are approximately positioned on this map

BUTLER COUNTY, KANSAS — SHEET NUMBER 42



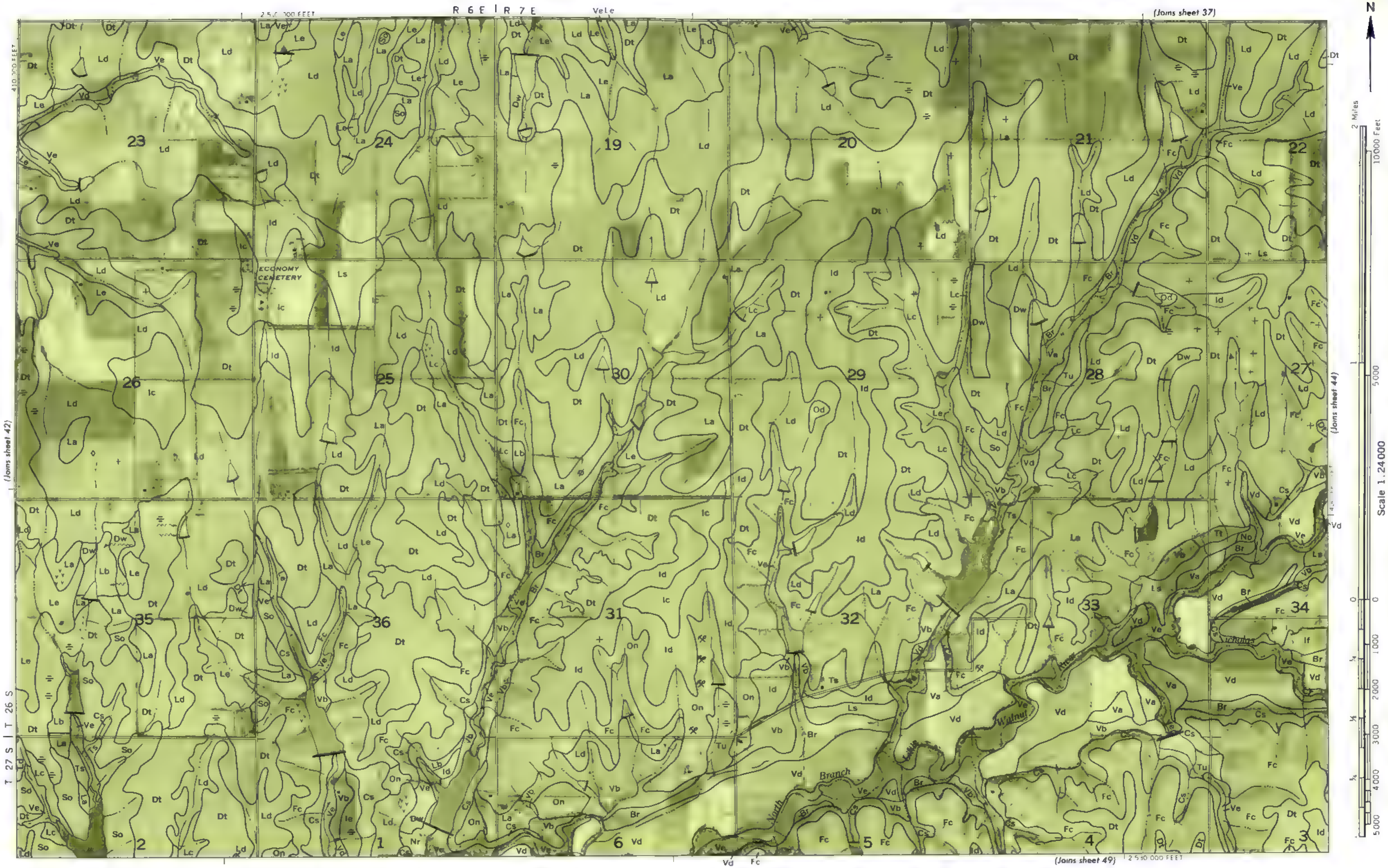
5000 AND 10000 FOOT GRID TICKS

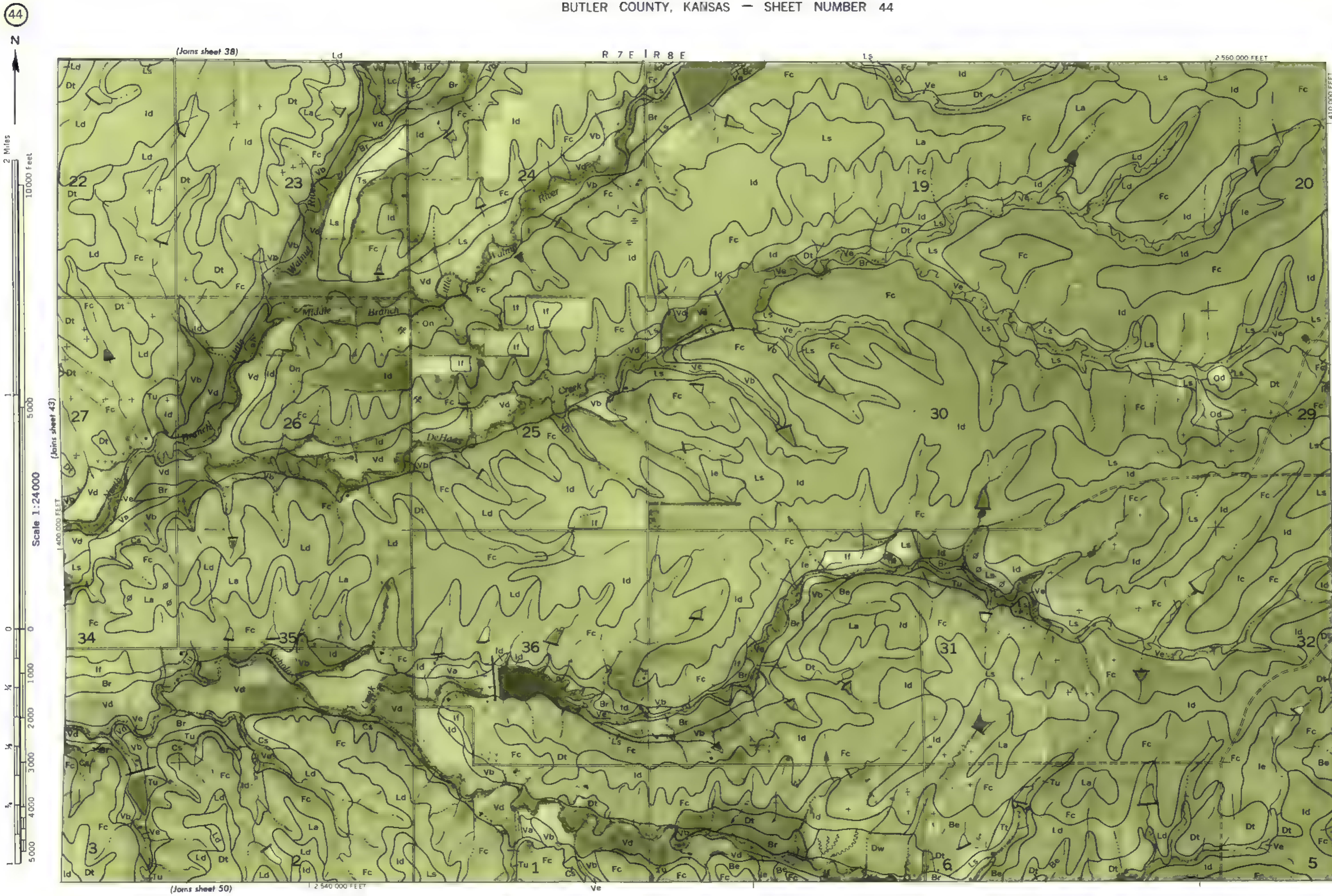
Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 10,000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station

BUTLER COUNTY, KANSAS NO. 42


43
N
R 6 E
R 7 E
(Joins sheet 37)
(Joins sheet 42)
(Joins sheet 44)
(Joins sheet 49)
T 26 S
T 27 S
ECONOMY CEMETERY
Walnut
North Branch
Scale 1:24 000
2 Miles
10000 Feet



Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

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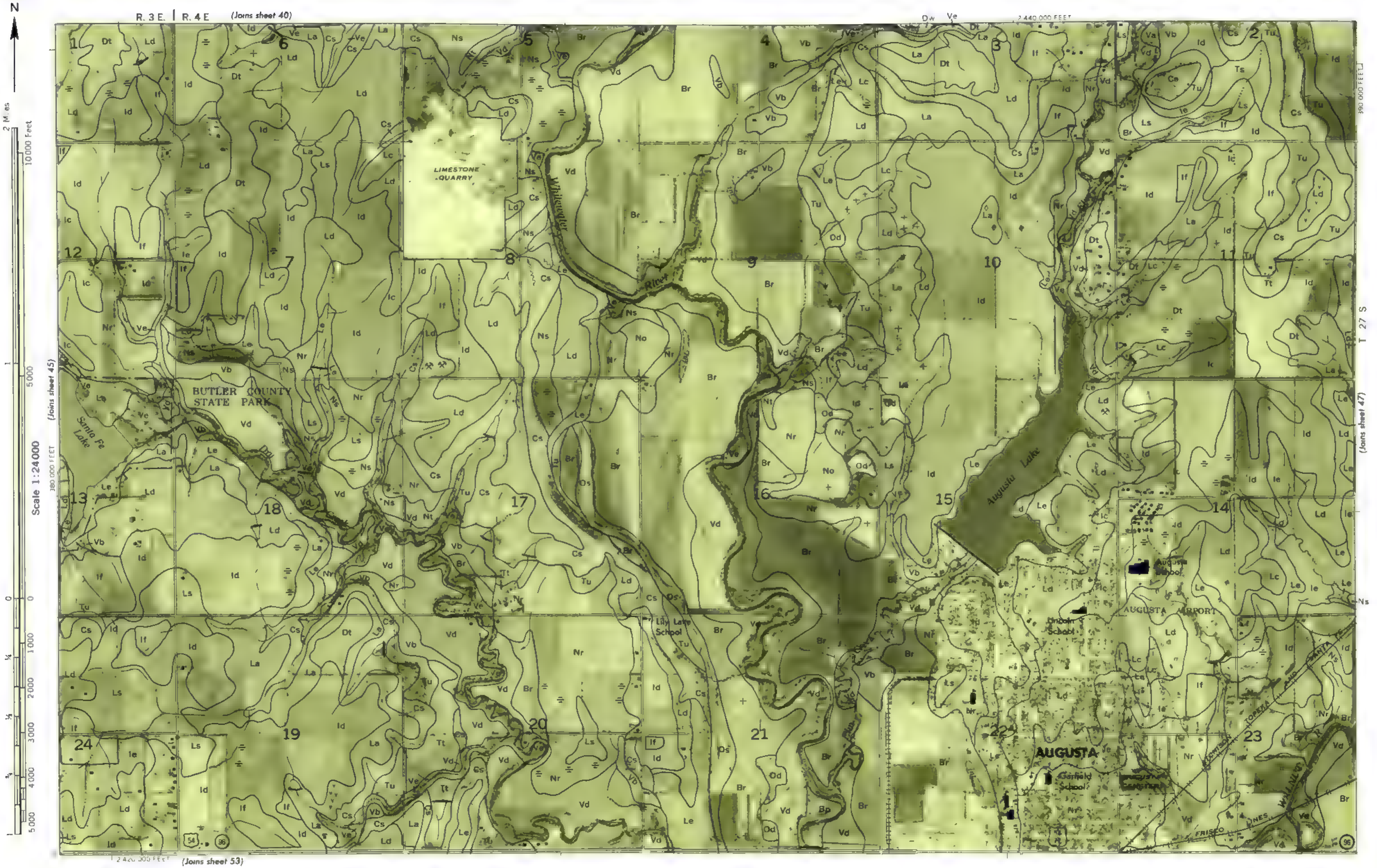
BUTLER COUNTY, KANSAS NO. 44


(Joins sheet 39)
R 3 E
2 390 000 FEET
390 000 FEET
ANDOVER CEMETERY
Sunset Acres
Andover
SEWAGE LAGOON
SHADY REST PARK
BUTLER COUNTY STATE PARK
Santa Fe Lake
(Joins sheet 46)
380 000 FEET
Camp Ta Wa Ko Ni
FRISCO LINES
Lorena
T 27 S
SEDGWICK COUNTY
Brookhaven
Cuckoo
St Vincent de Paul Church
Midway
2 410 000 FEET
(Joins sheet 52)
N
2 Miles
10 000 Feet
Scale 1:24 000

BUTLER COUNTY, KANSAS — SHEET NUMBER 46



Land division corners are approximately positioned on this map

Photobase from 197_ aerial photography. Positions of ... grid ticks are approximate and based on the Kansas coordinate system, south zone

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station

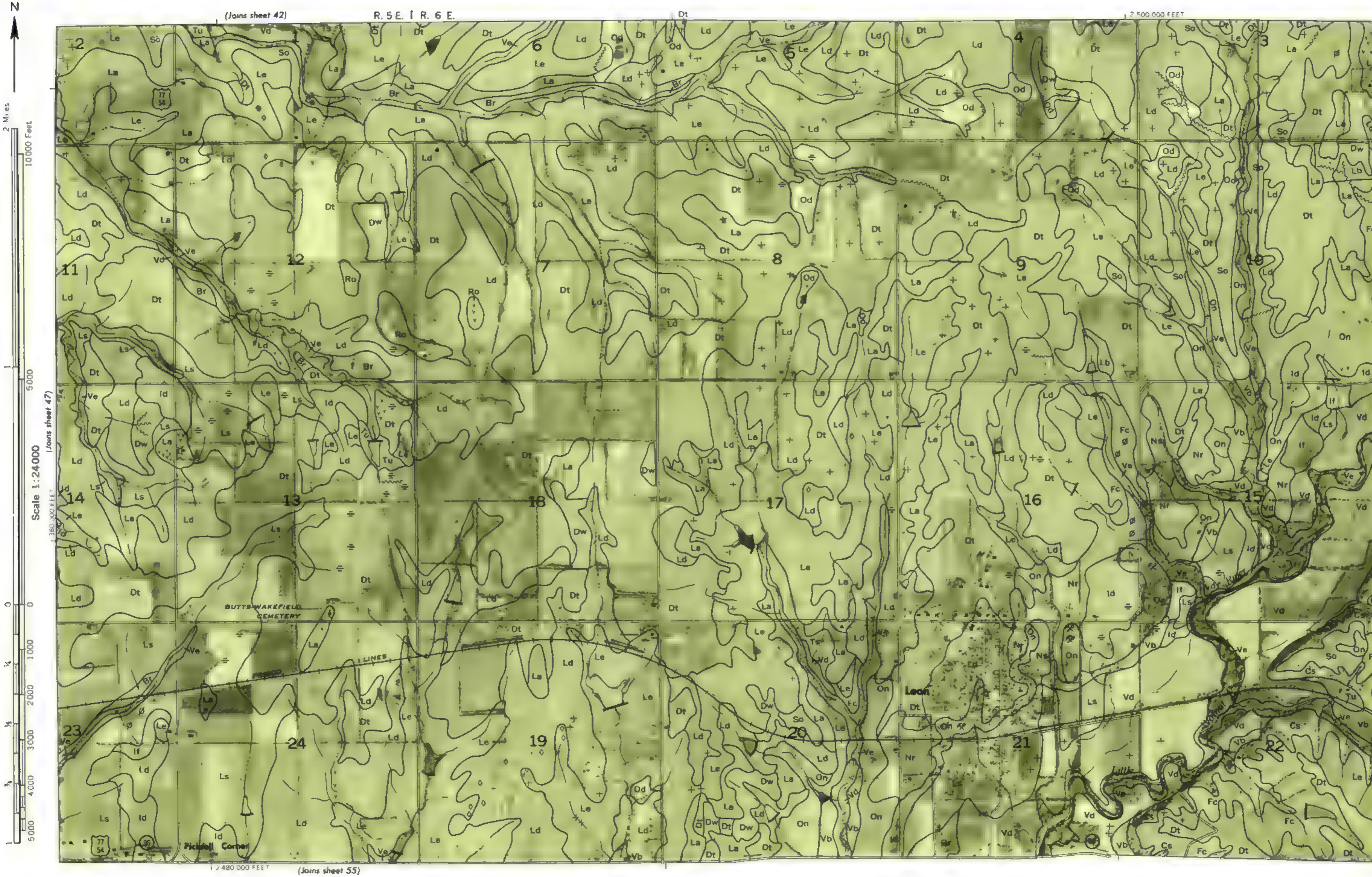
BUTLER COUNTY, KANSAS NO. 46

BUTLER COUNTY, KANSAS NO. 47

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

Photobase from [illegible] aerial photography. Positions of 10,000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

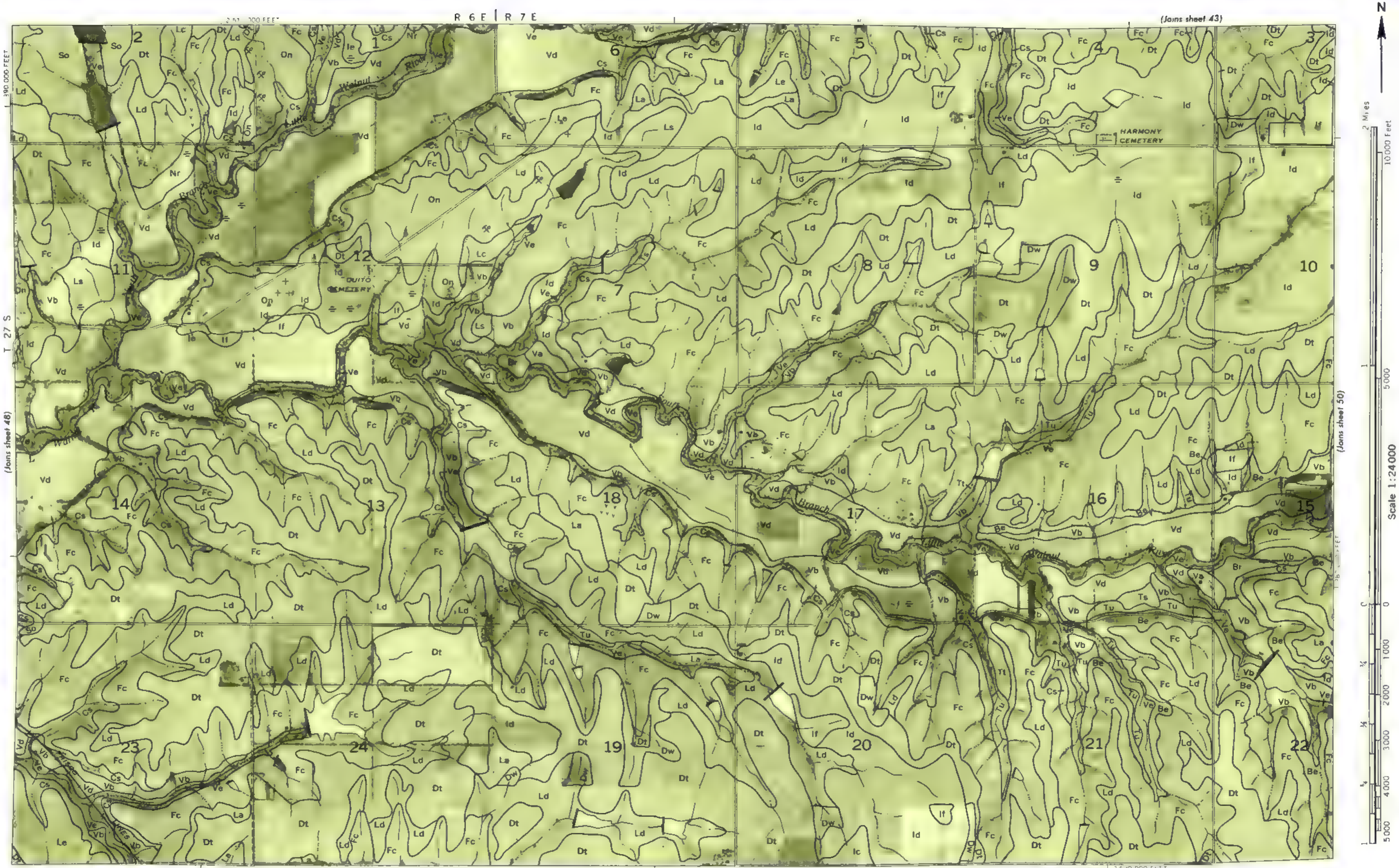
Land division corners are approximately positioned on this map.

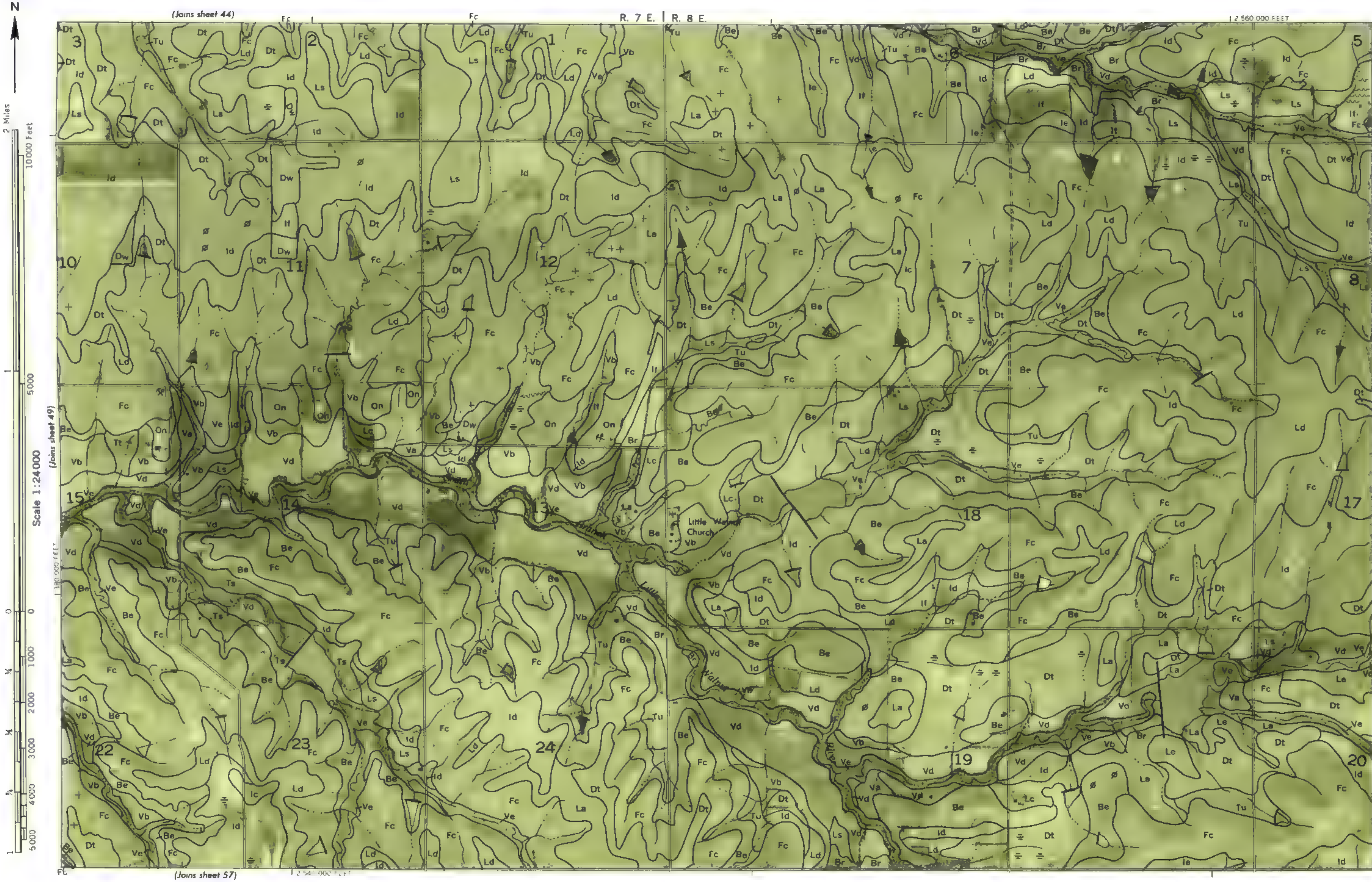


Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10,000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.


N
R 6 E | R 7 E
(Joins sheet 43)
(Joins sheet 48)
(Joins sheet 50)
(Joins sheet 56)
T 27 S
HARMONY CEMETERY
QUITO CEMETERY
Walnut River
Branch
Scale 1:24 000
2 Miles
10000 Feet
Land division corners are approximately positioned on this map

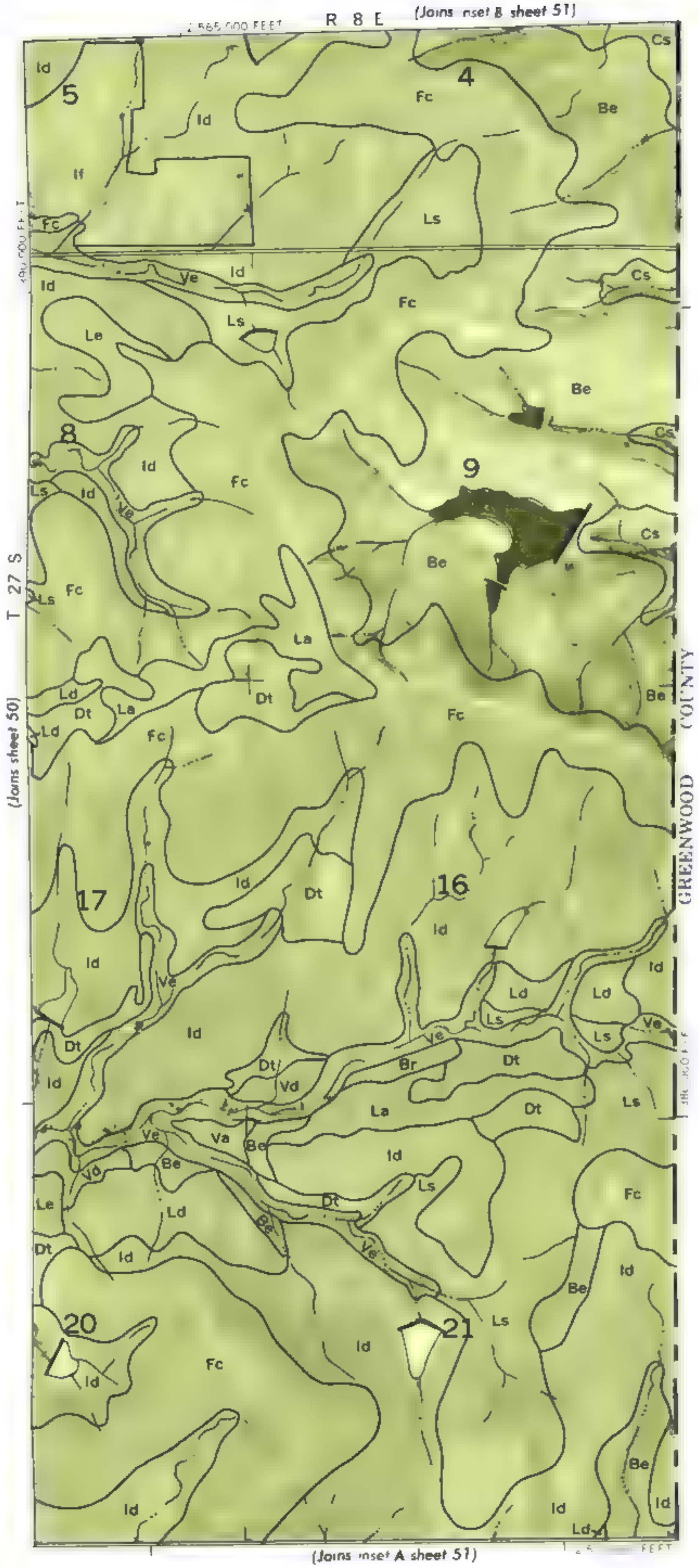


Land division corners are approximately positioned on this map

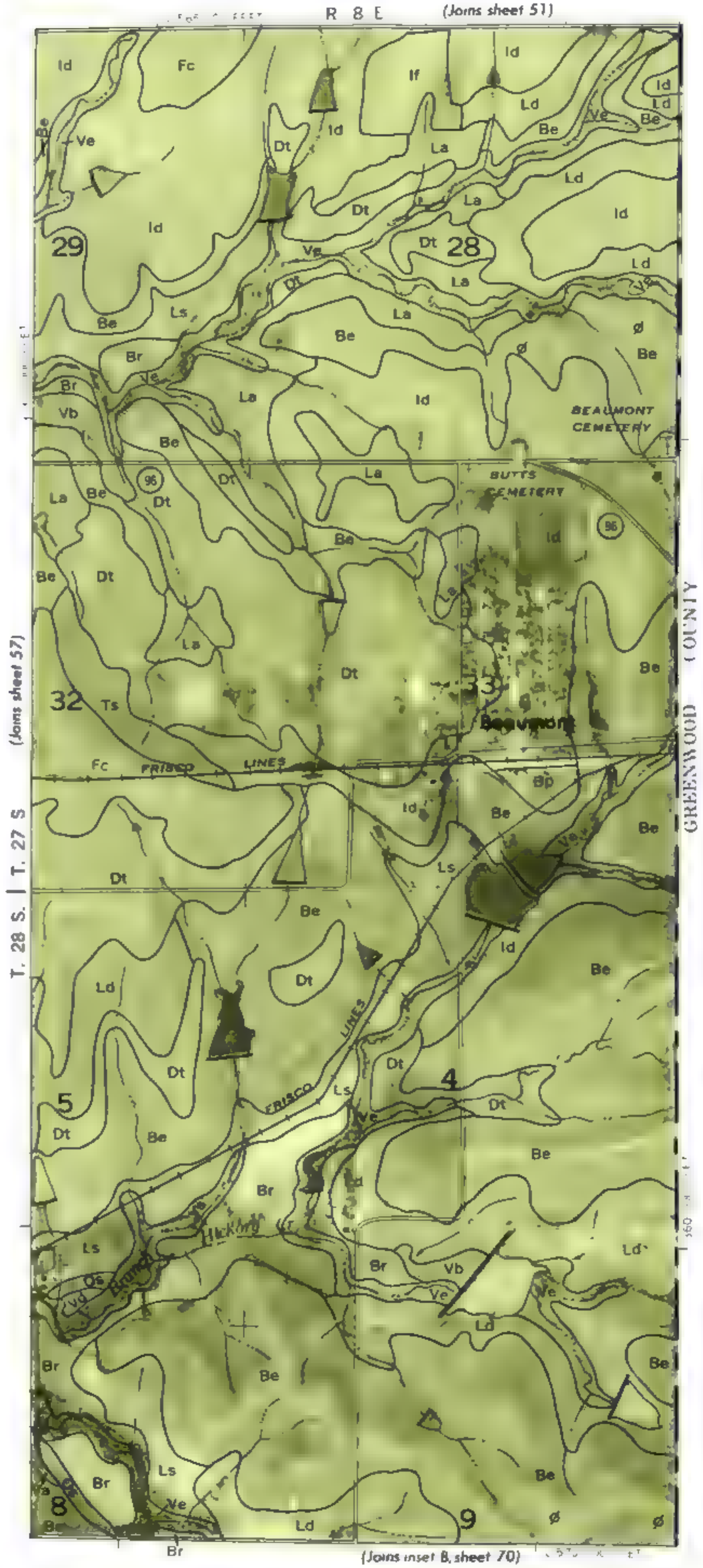
Photobase from 1970 aerial photography. Positions of 10 000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station

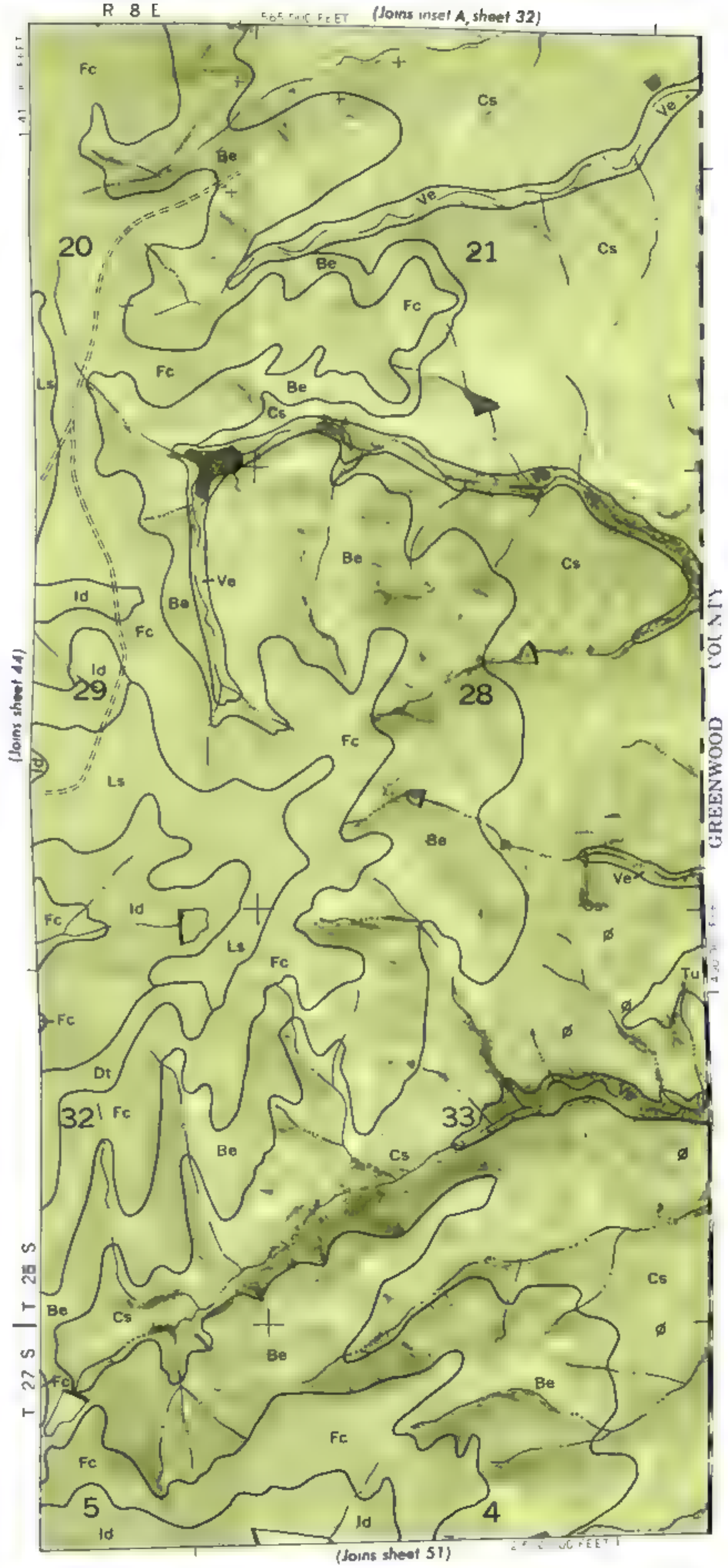
BUTLER COUNTY, KANSAS NO. 50

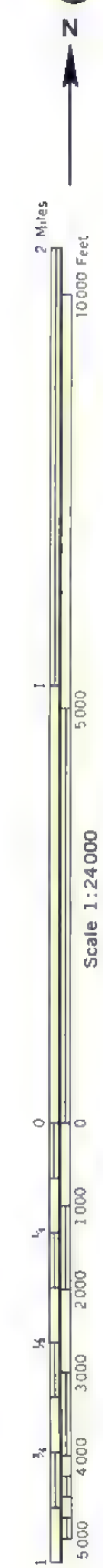


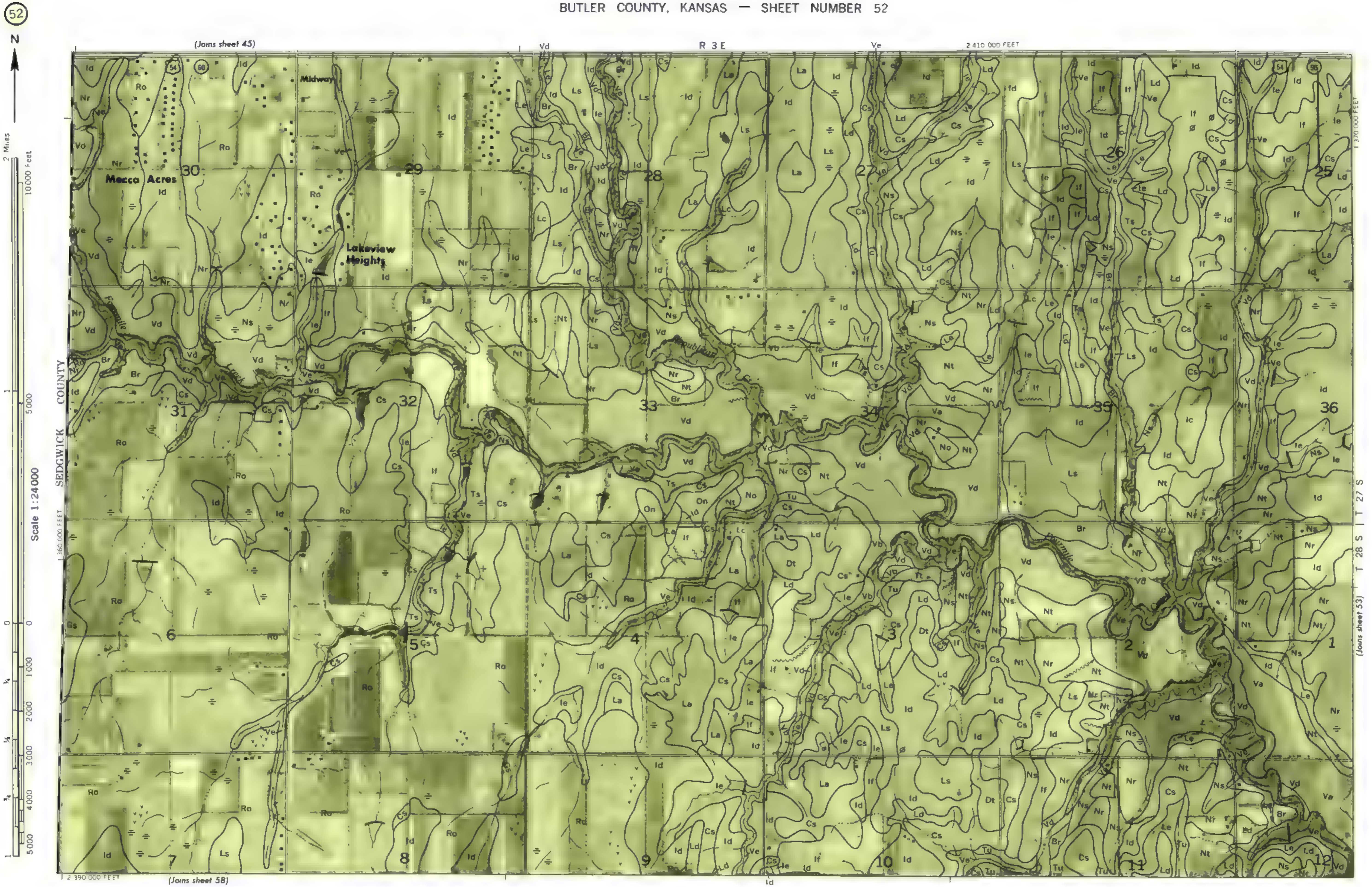
INSET A



INSET B







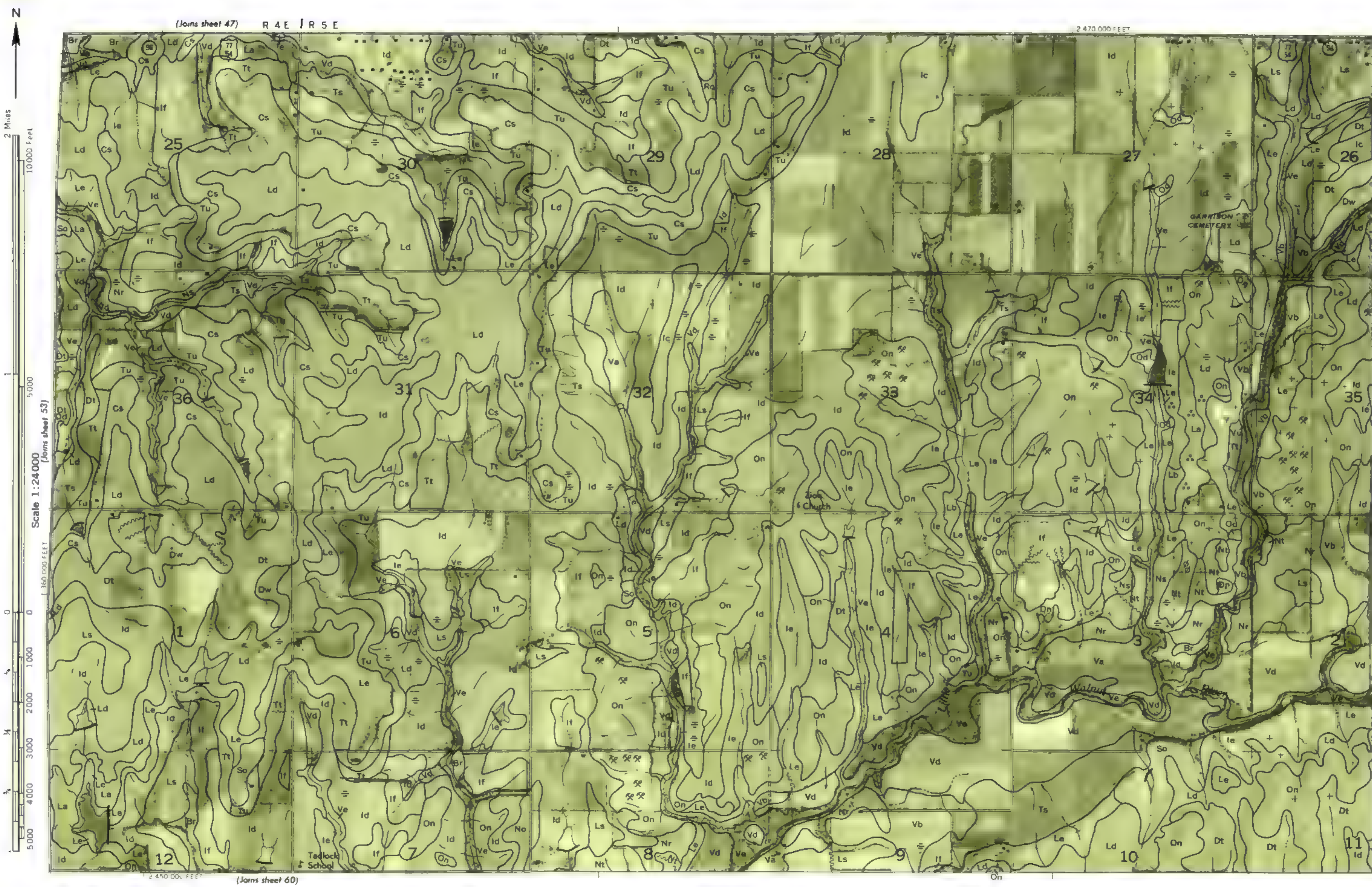
Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 10 000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station

BUTLER COUNTY, KANSAS NO. 52


R 3 E
R 4 E
2 420 000 FEET
470 000 FEET
(Joins sheet 46)
(Joins sheet 52)
(Joins sheet 54)
(Joins sheet 59)
AUGUSTA
FRISCO LINES
Oil Refinery
Whitewater River
Walnut River
ATCHISON TOPEKA AND SANTA FE
LIMESTONE QUARRY
GOLDEN CEMETERY
T 27 S
T 28 S
N
Scale 1:24000
2 Miles
10000 Feet

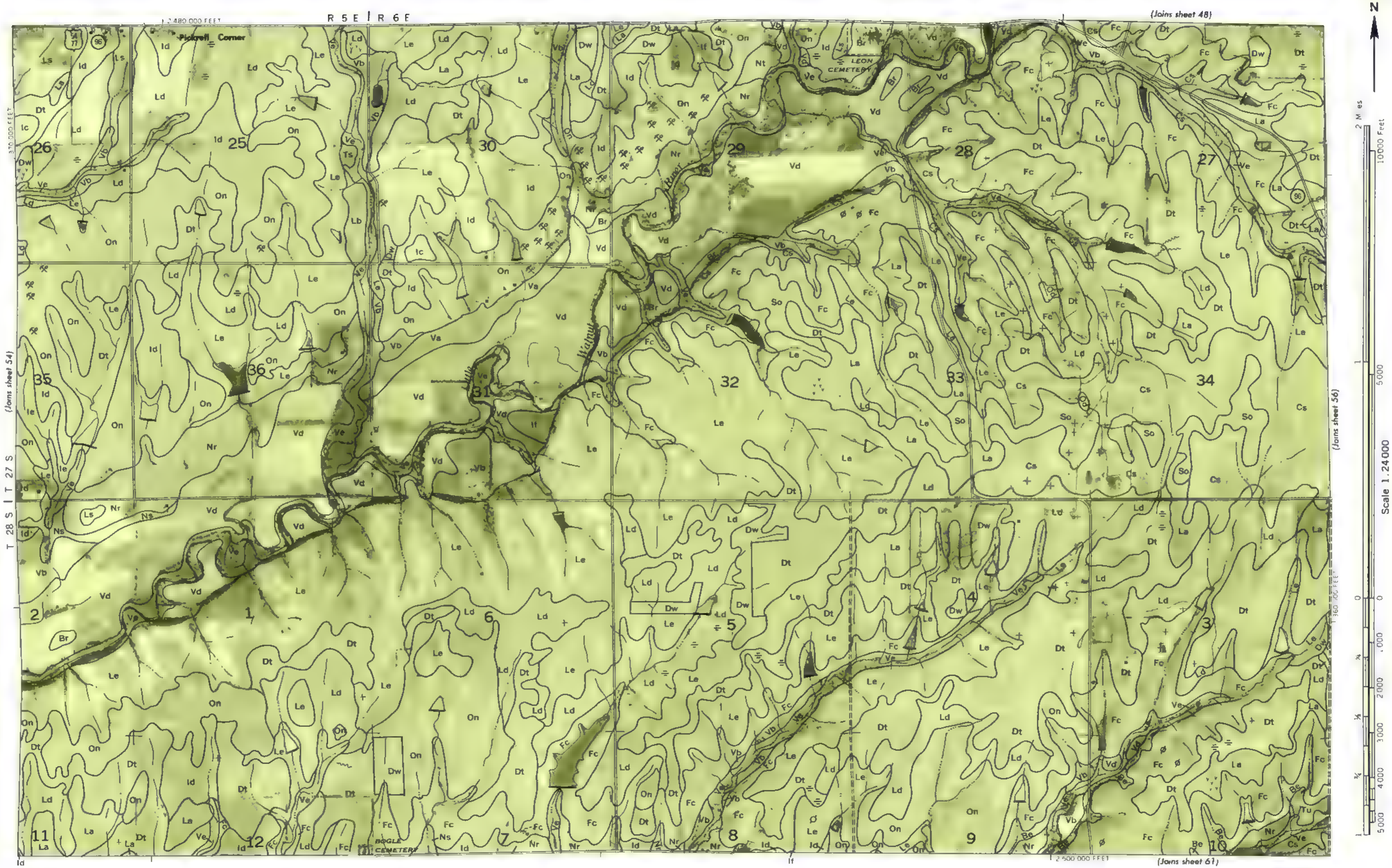


Land division corners are approximately positioned on this map.

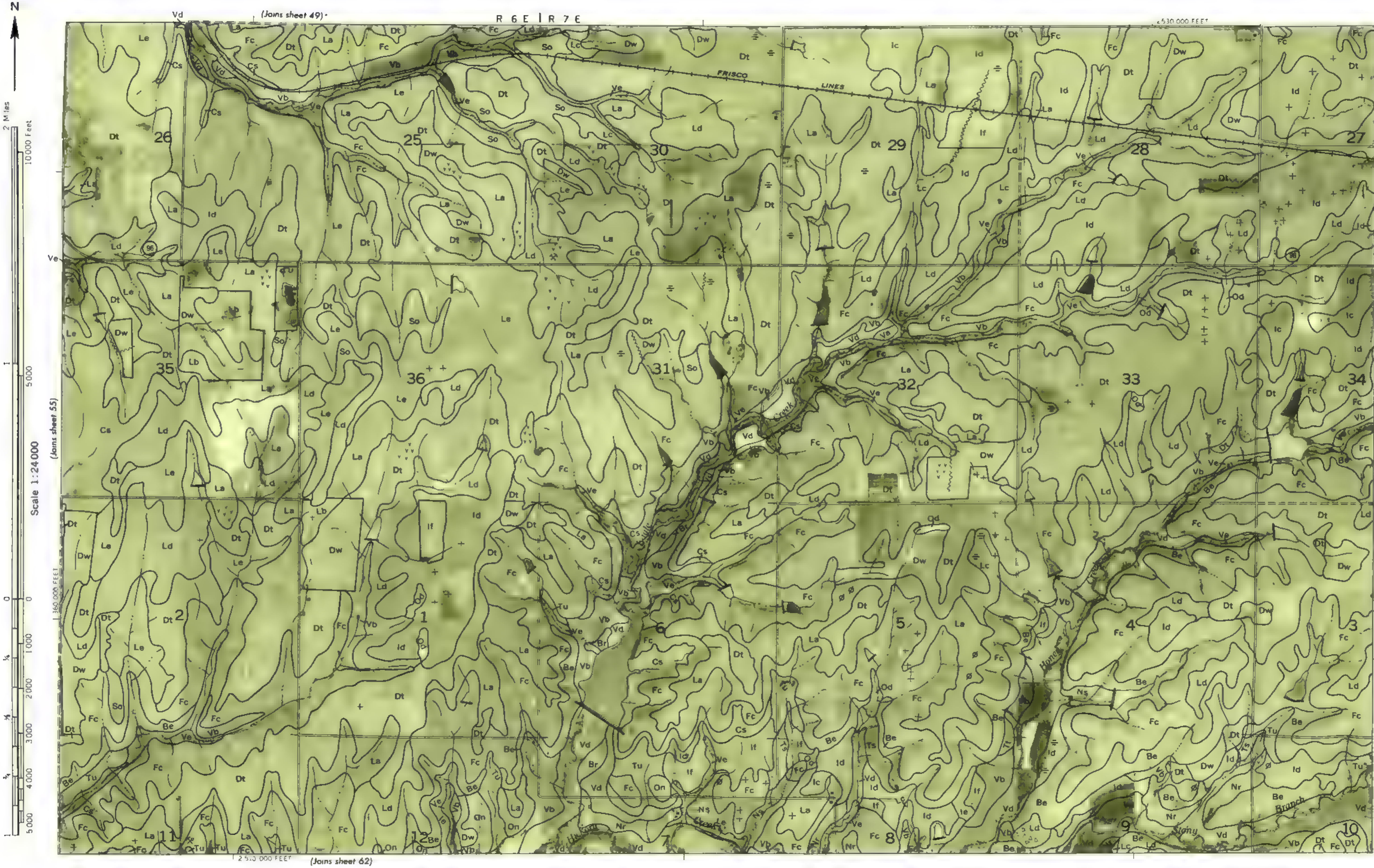
Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

BUTLER COUNTY, KANSAS NO. 54


R 5 E | R 6 E
2 480 000 FEET
(Joins sheet 48)
Pickrell Corner
LEON CEMETERY
Walnut
(Joins sheet 54)
(Joins sheet 56)
T 27 S
T 28 S
370 000 FEET
360 000 FEET
BOGLE CEMETERY
2 500 000 FEET
(Joins sheet 61)
N
Scale 1:24 000
2 Miles
10 000 Feet
Land division corners are approximately positioned on this map

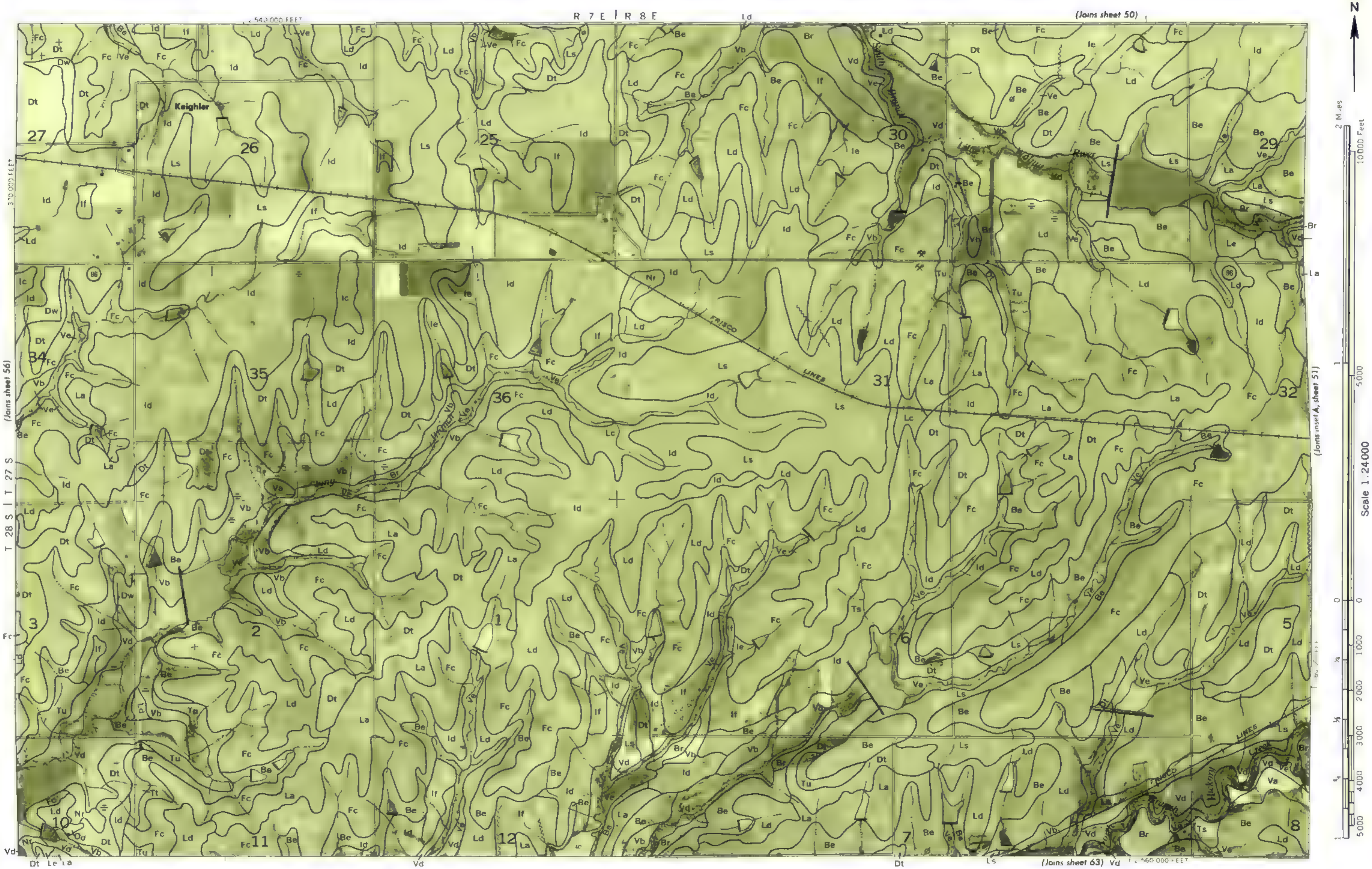
BUTLER COUNTY, KANSAS — SHEET NUMBER 56



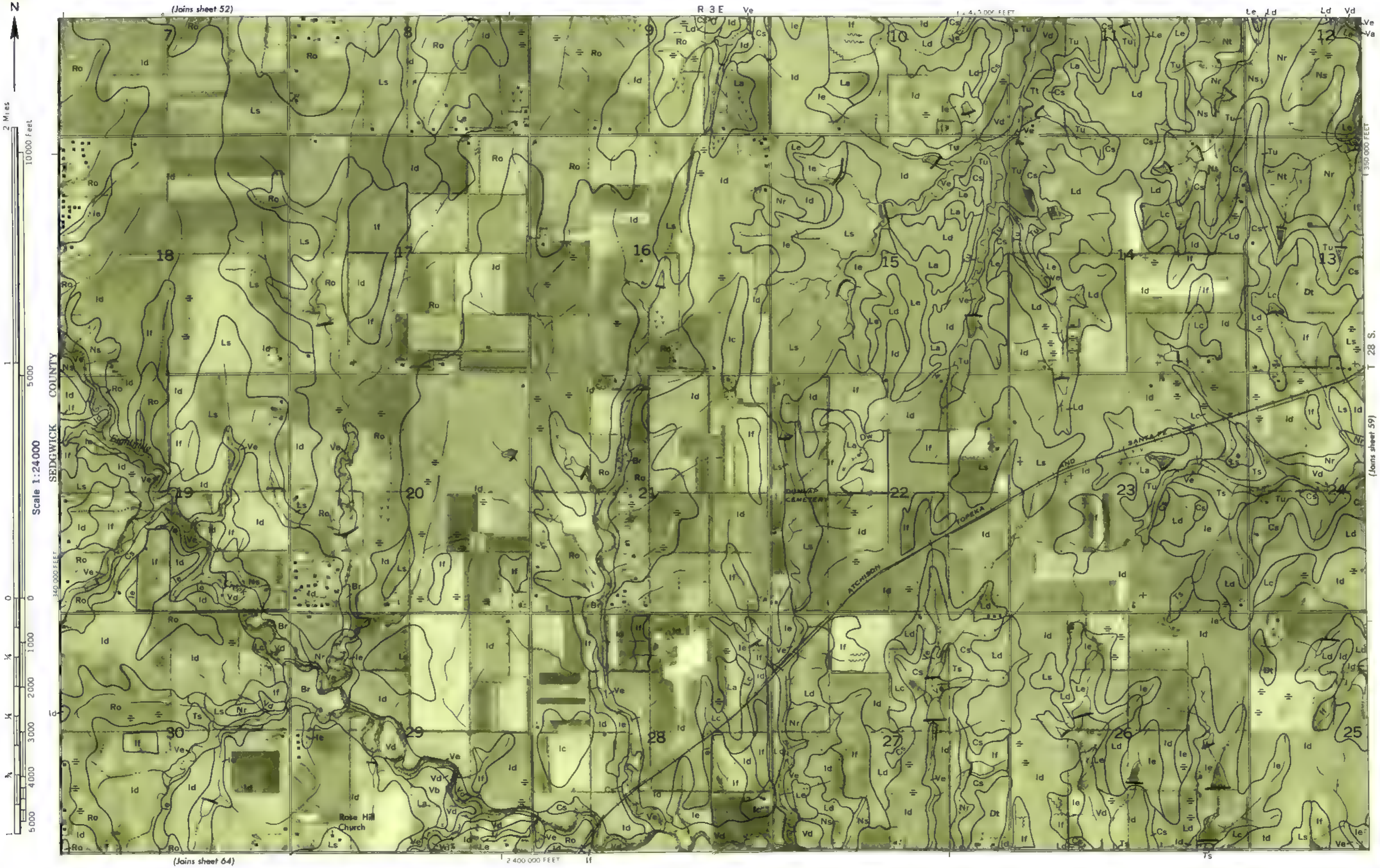
Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.


N
R 7 E | R 8 E
(Joins sheet 50)
(Joins sheet 56)
(Joins inset A, sheet 51)
(Joins sheet 63)
T 27 S | T 28 S
Keighler
FRISCO LINES
South Branch
Walnut River
Hickory Creek
540 000 FEET
560 000 FEET
370 000 FEET
27
26
25
30
29
34
35
36
31
32
3
2
1
6
5
10
11
12
7
8
Scale 1:24 000
2 Miles
10 000 Feet
1
5000
0
1000
2000
3000
4000
5000

BUTLER COUNTY, KANSAS — SHEET NUMBER 58



Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 10 000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone

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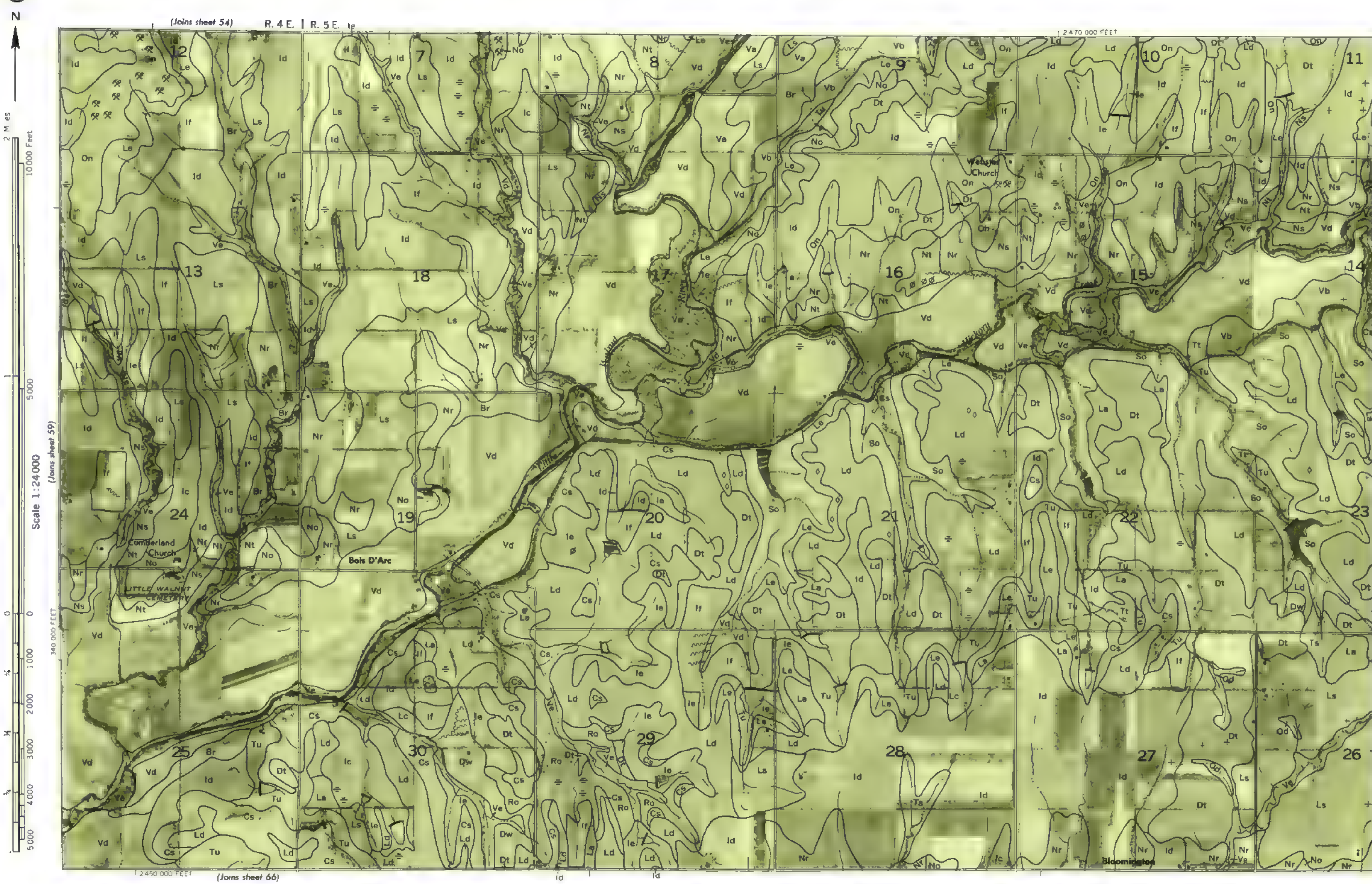
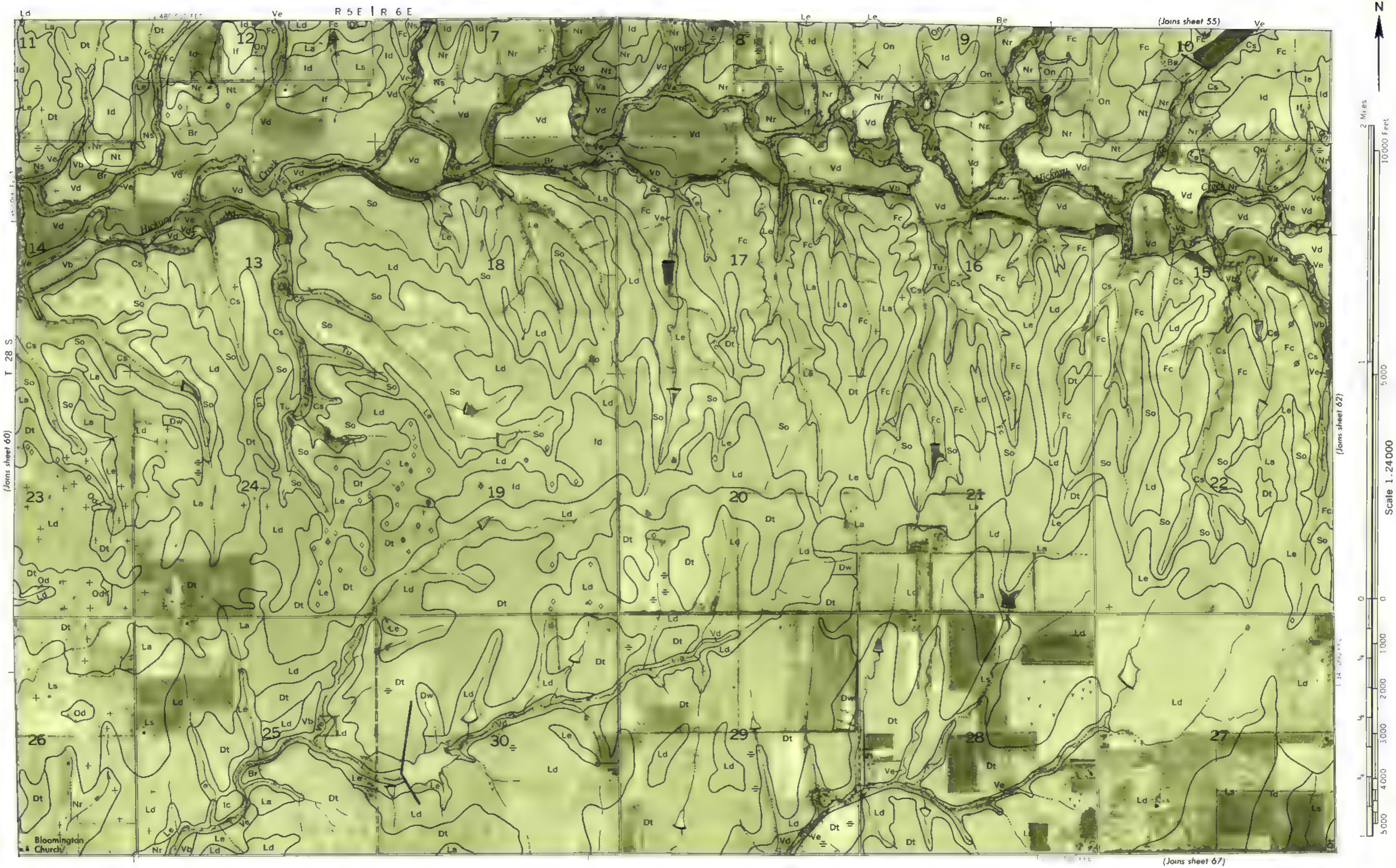
BUTLER COUNTY, KANSAS NO. 58

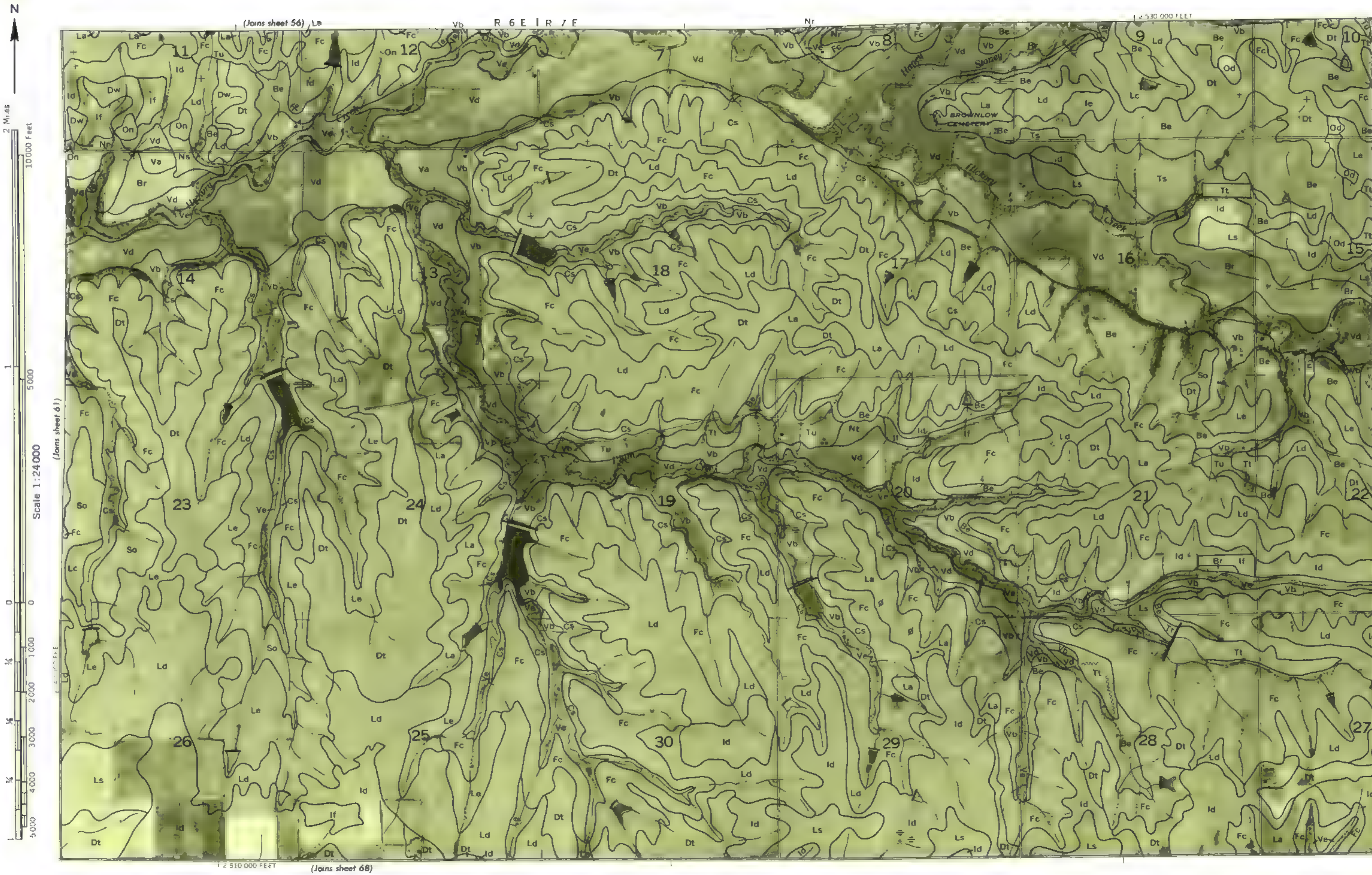

R 3 E
R 4 E
T 28 S
(Joins sheet 53)
(Joins sheet 58)
(Joins sheet 60)
(Joins sheet 65)
FAIRVIEW CEMETERY
Floral School
Salter
Gordon
ATCHISON TOPEKA AND SANTA FE
WALNUT
RIVER
N
Scale 1:24000
2 Miles
5000 Feet
2 440 000 FEET

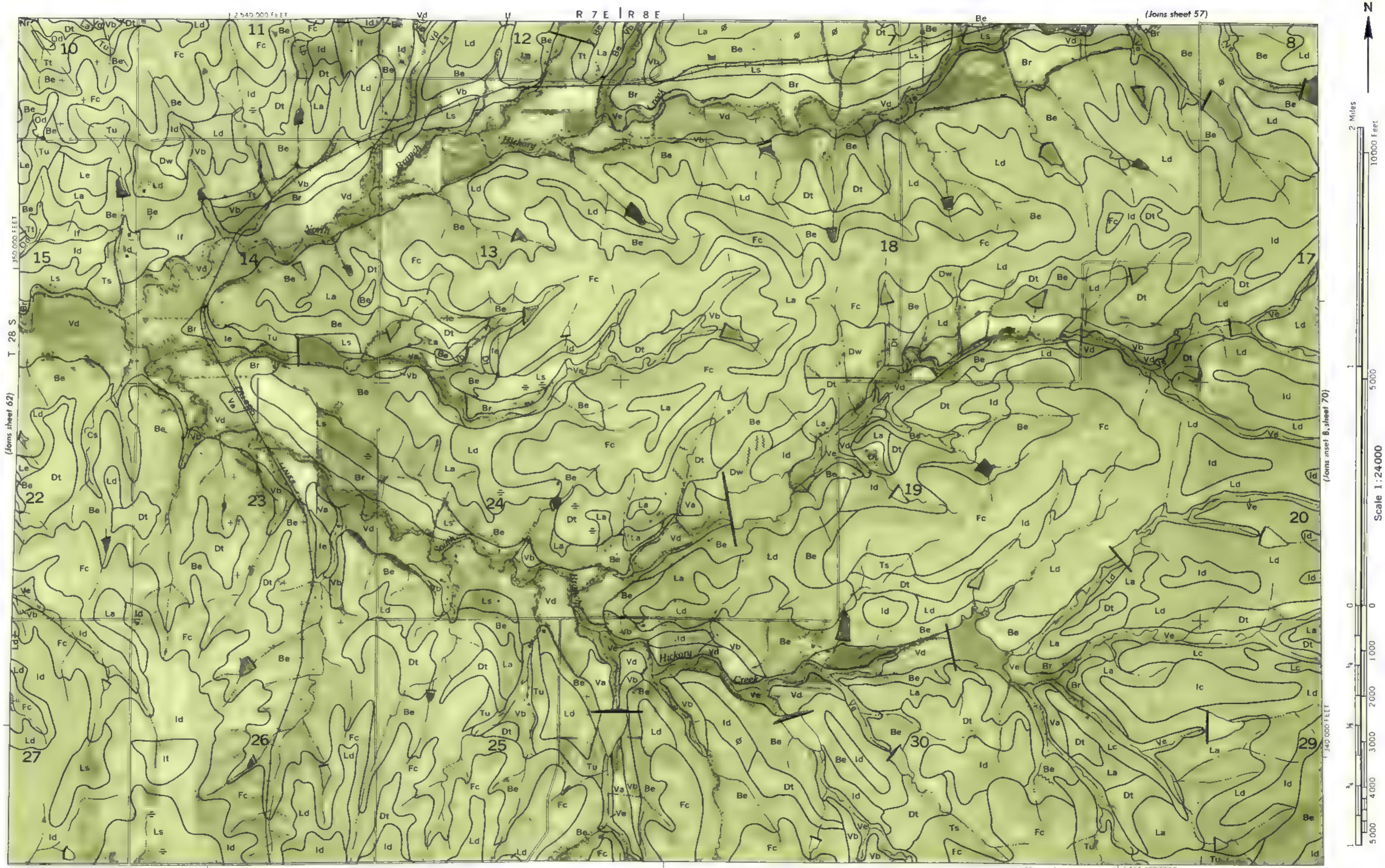


BUTLER COUNTY, KANSAS NO. 60

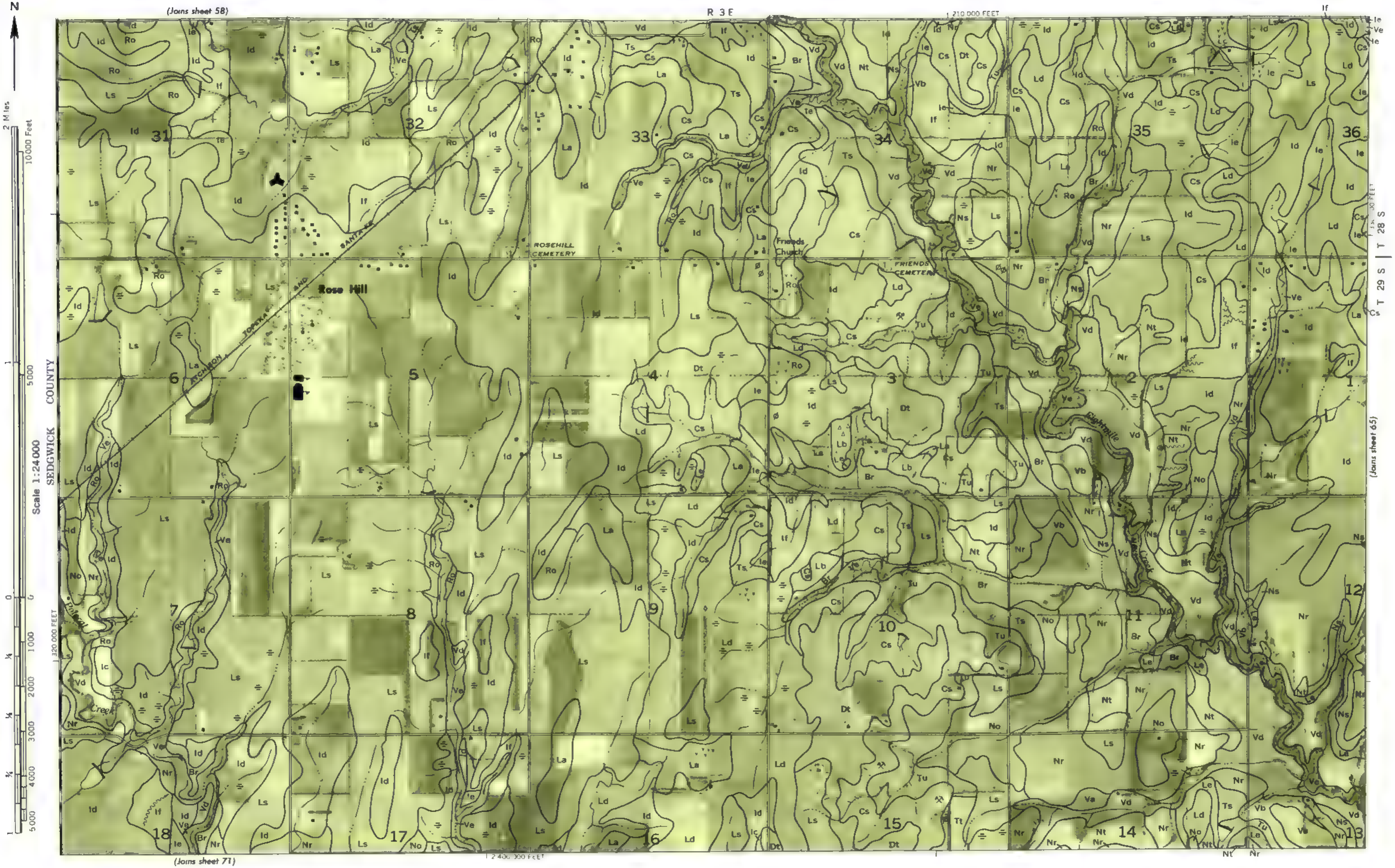

R 5 E | R 6 E
(Joins sheet 55)
(Joins sheet 60)
(Joins sheet 62)
(Joins sheet 67)
T 28 S
N
Scale 1:24000
Hickory Creek
Bloomington Church

BUTLER COUNTY, KANSAS — SHEET NUMBER 62




N
R 7 E
R 8 E
T 28 S
(Joins sheet 57)
(Joins sheet 62)
(Joins inset B, sheet 70)
(Joins sheet 69)
2 540 000 FEET
2 560 000 FEET
350 000 FEET
340 000 FEET
Scale 1:24000
2 Miles
10000 Feet
Hickory
Branch
Hickory Creek
10
11
12
7
8
15
14
13
18
17
22
23
24
19
20
27
26
25
30
29

BUTLER COUNTY, KANSAS — SHEET NUMBER 64

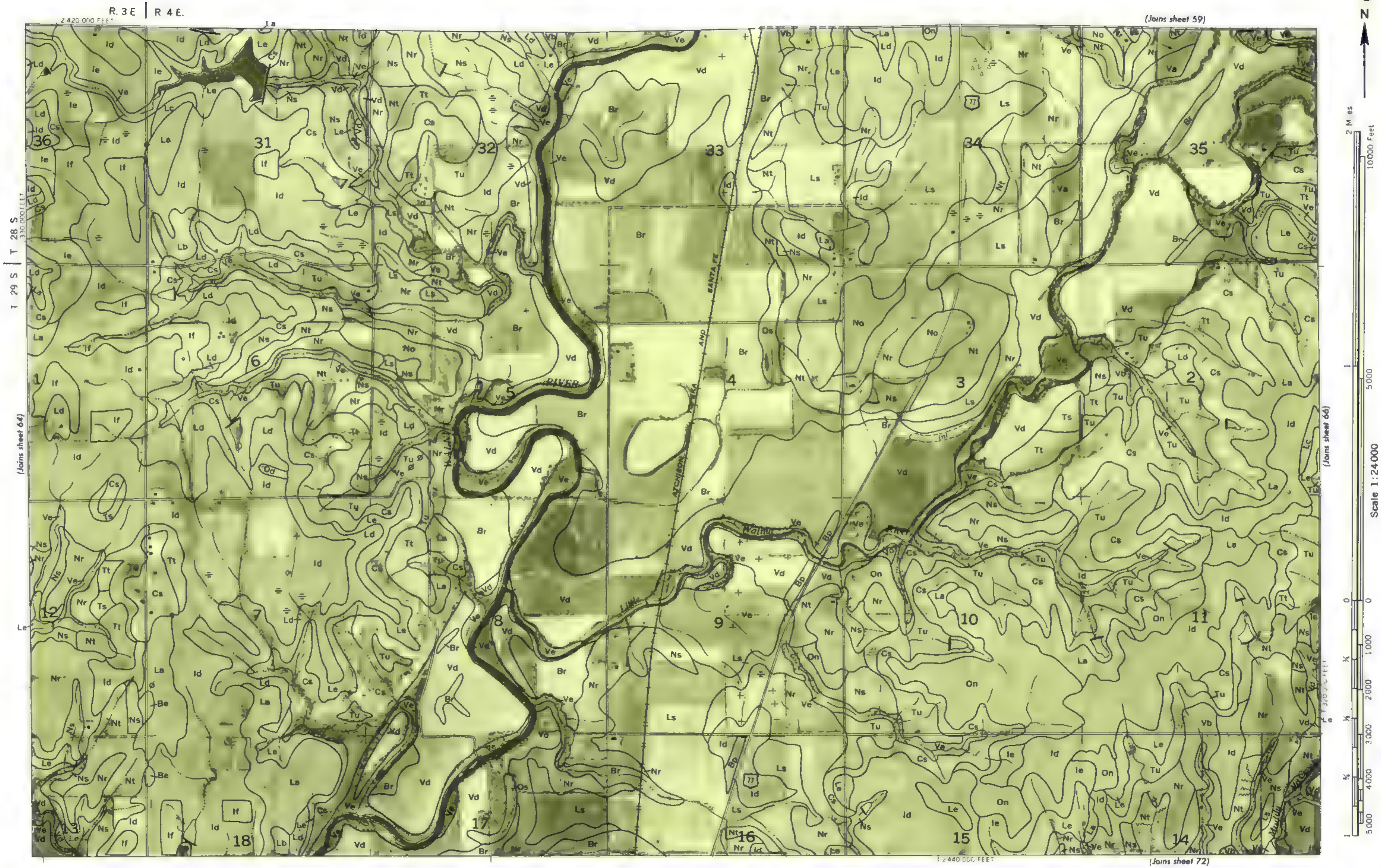


Land division corners are approximately positioned on this map.

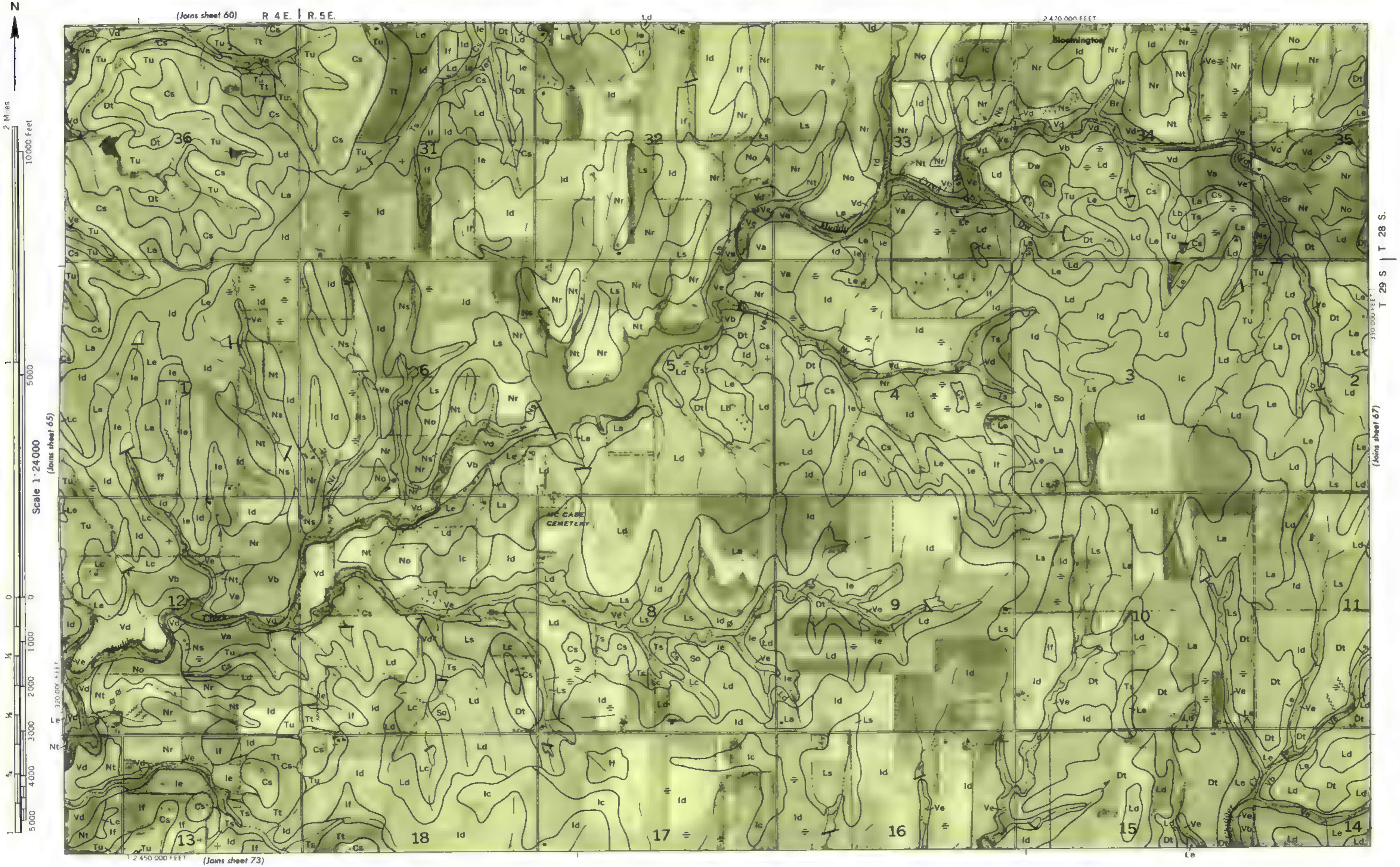
Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

65


R. 3 E.
R. 4 E.
2 420 000 FEET
(Joins sheet 59)
(Joins sheet 64)
(Joins sheet 66)
(Joins sheet 72)
T. 28 S.
T. 29 S.
N
Scale 1:24 000
2 Miles
10 000 Feet
5000
0
1000
2000
3000
4000
5000
1
½
¼
RIVER
Walnut
Little
ATCHISON AND SANTA FE
31
32
33
34
35
36
6
5
4
3
2
1
7
8
9
10
11
12
18
17
16
15
14
13

BUTLER COUNTY, KANSAS — SHEET NUMBER 66



Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 10 000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone

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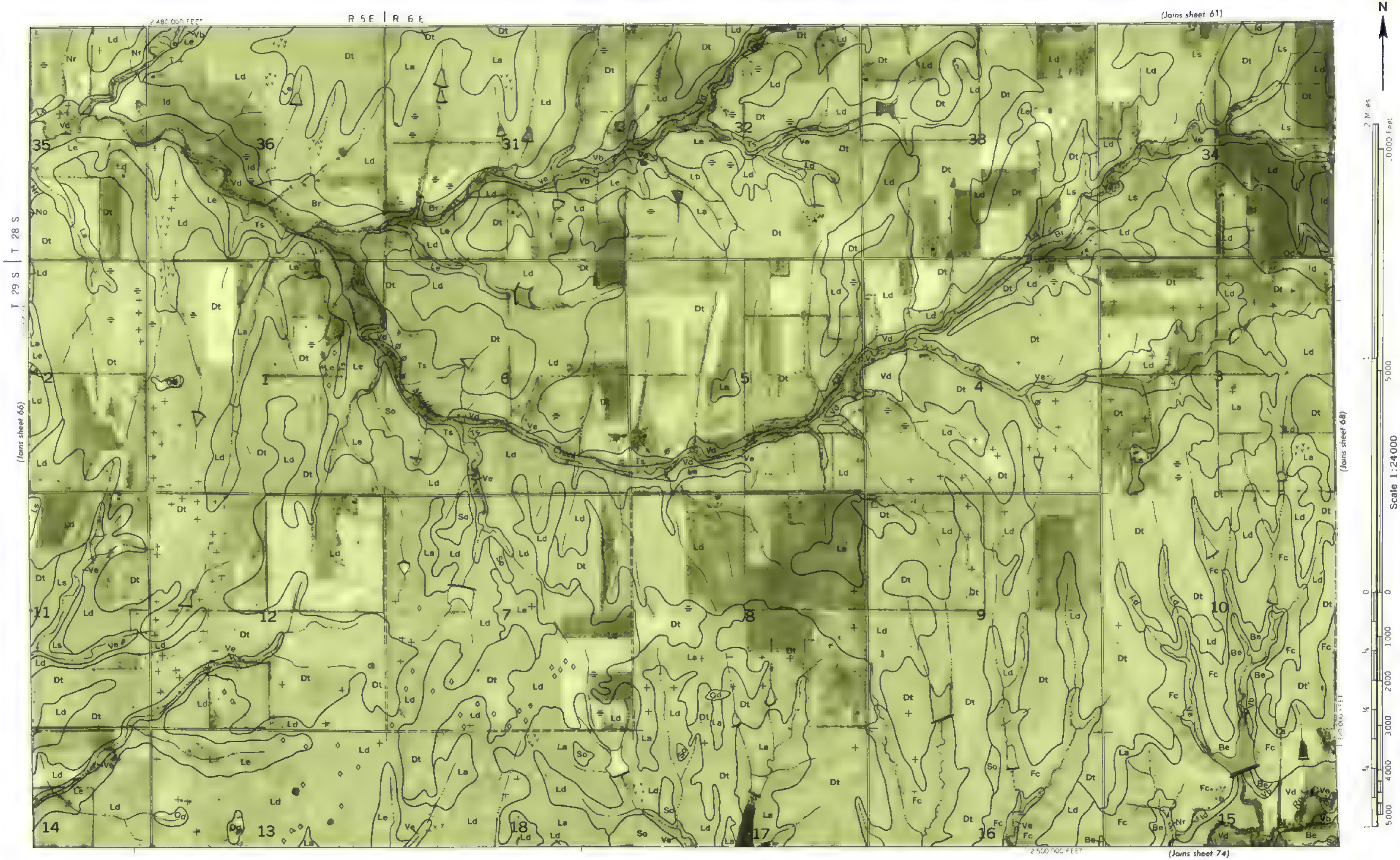
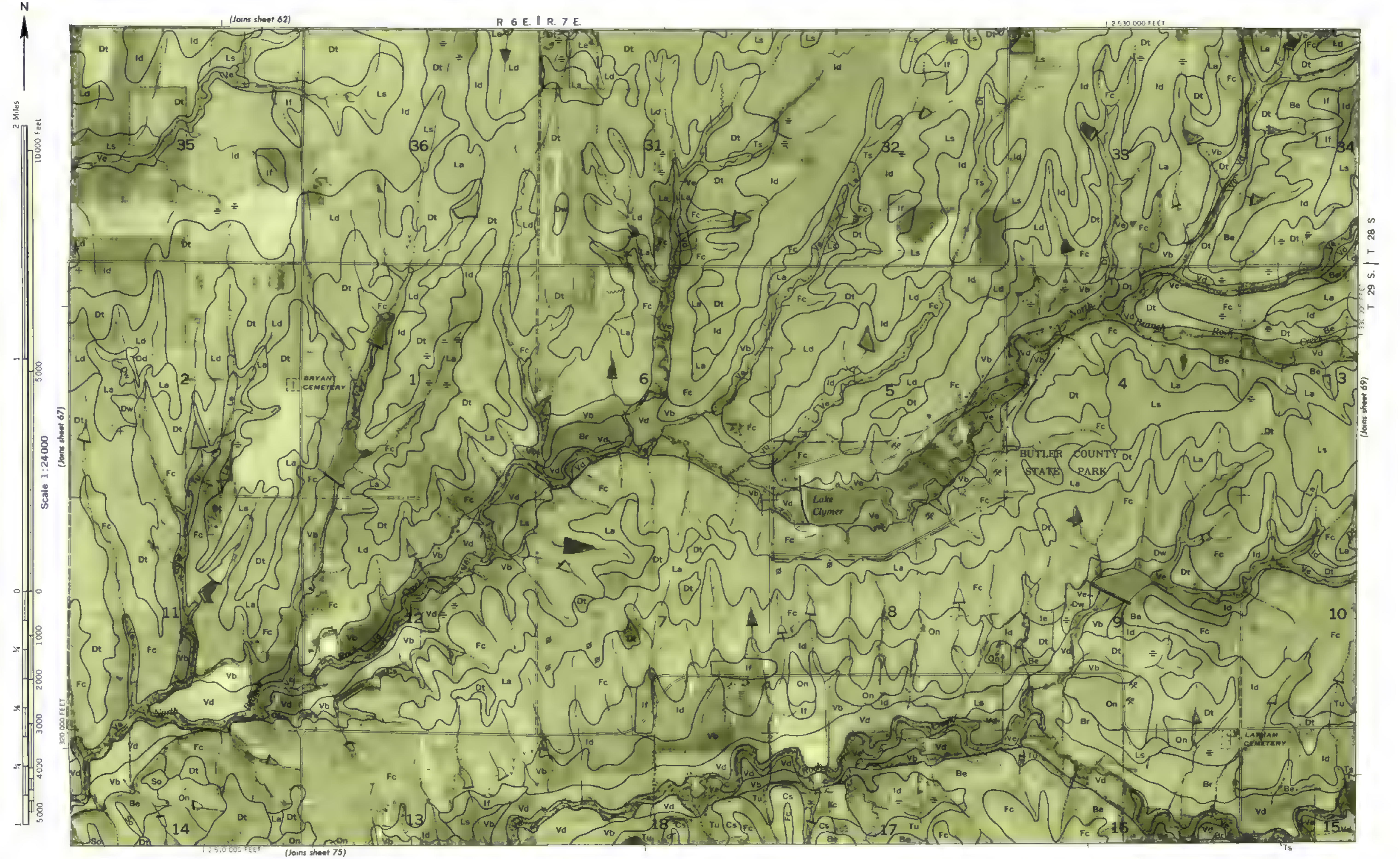
BUTLER COUNTY, KANSAS NO. 66

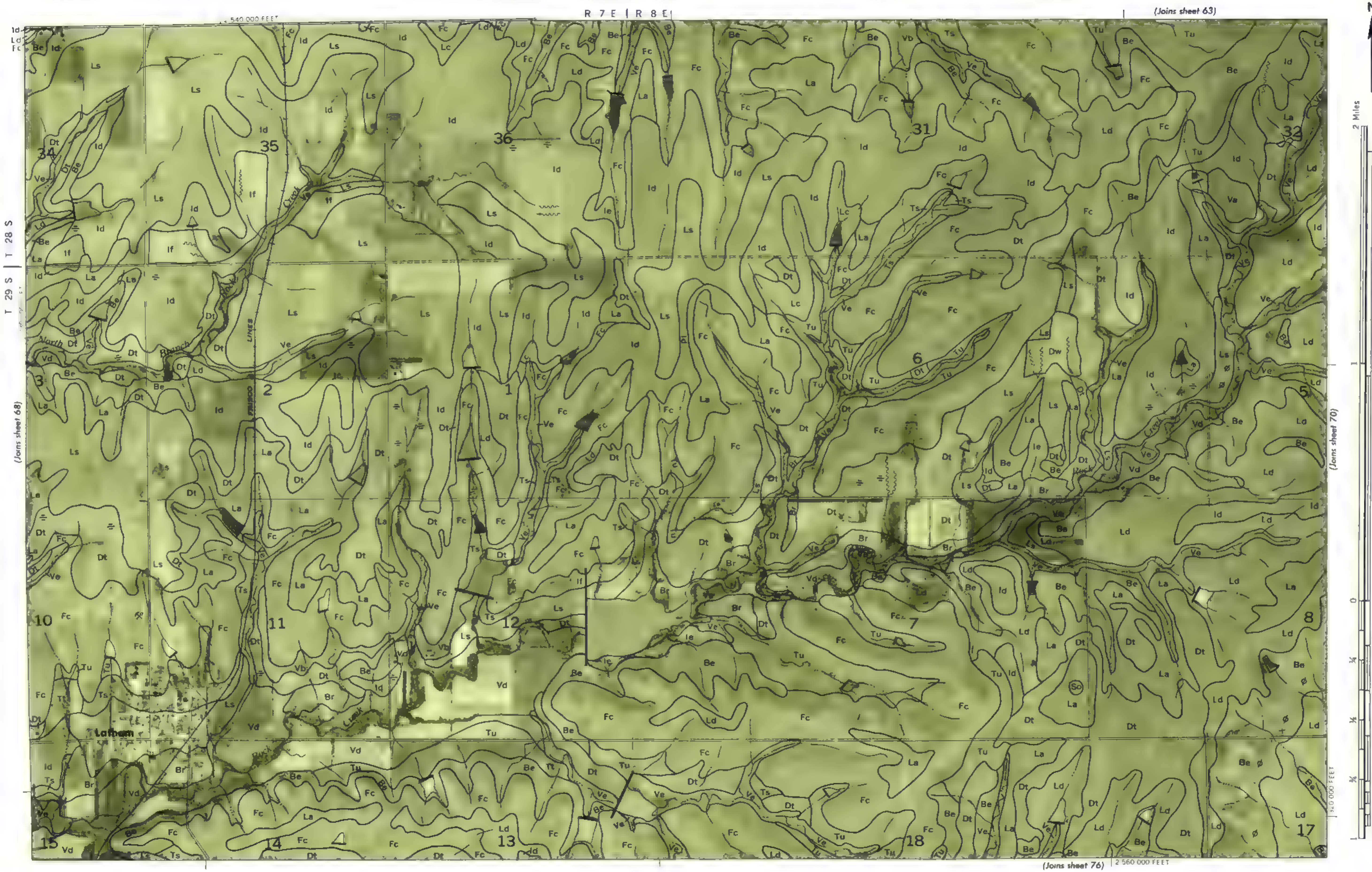


Land division corners are approximately positioned on this map



Land division corners are approximately positioned on this map

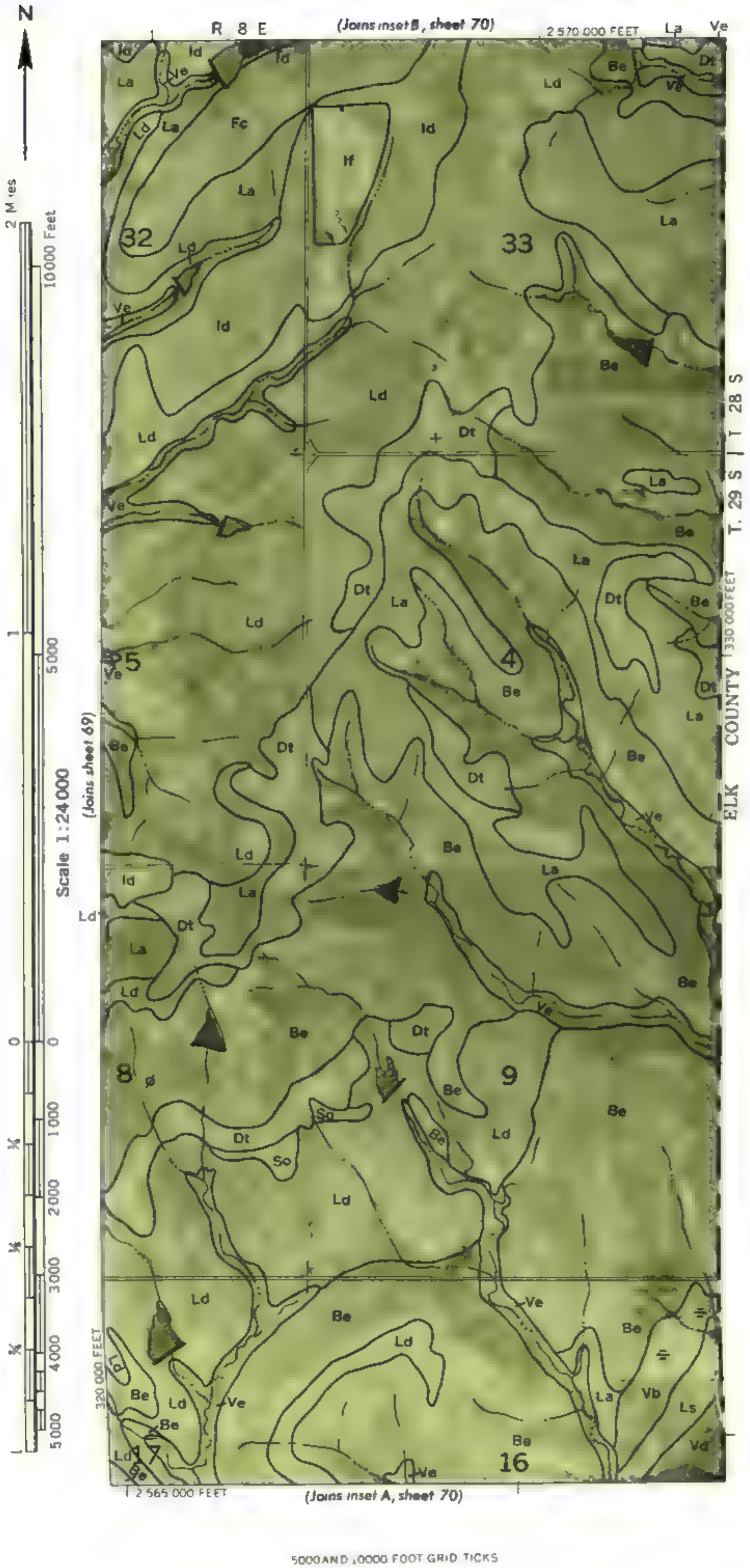
BUTLER COUNTY KANSAS NO 68



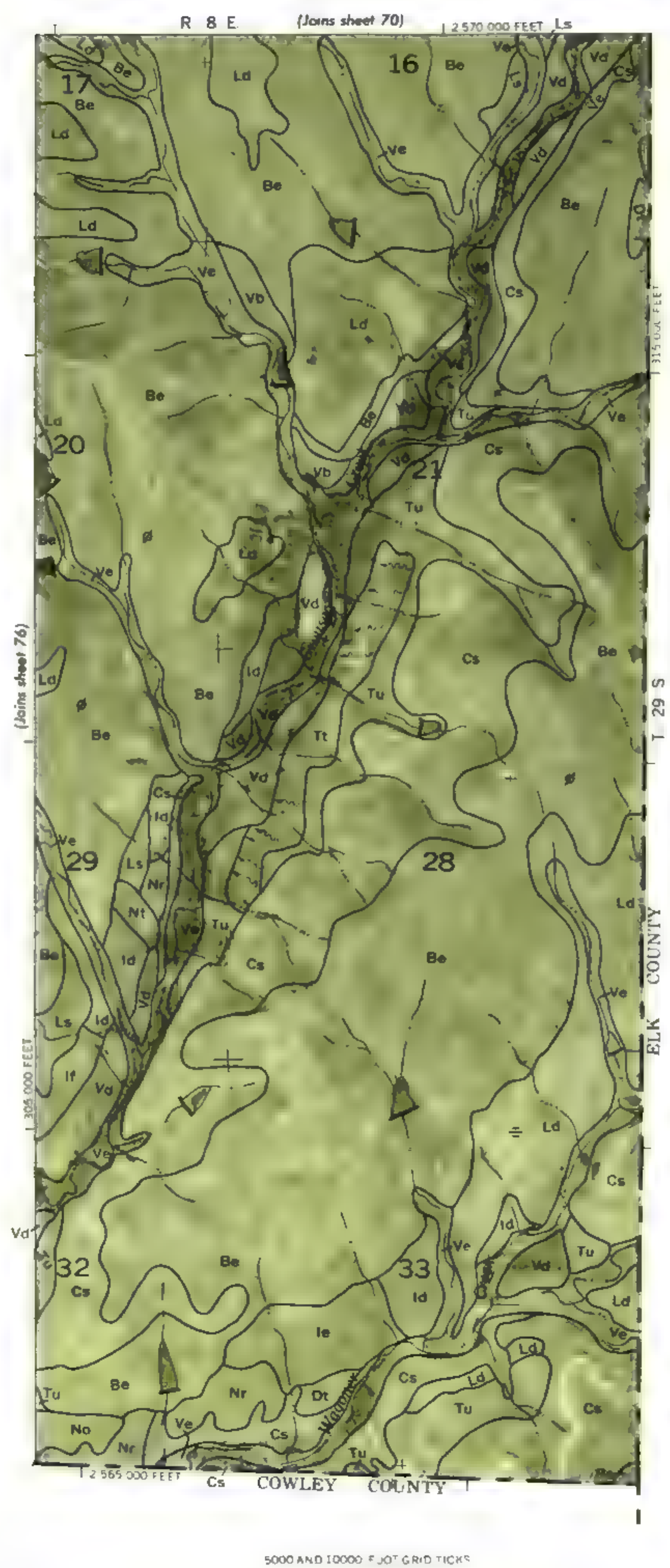
BUTLER COUNTY, KANSAS NO. 69

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.
Photobase from [illegible] aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.
Land division corners are approximately positioned on this map.

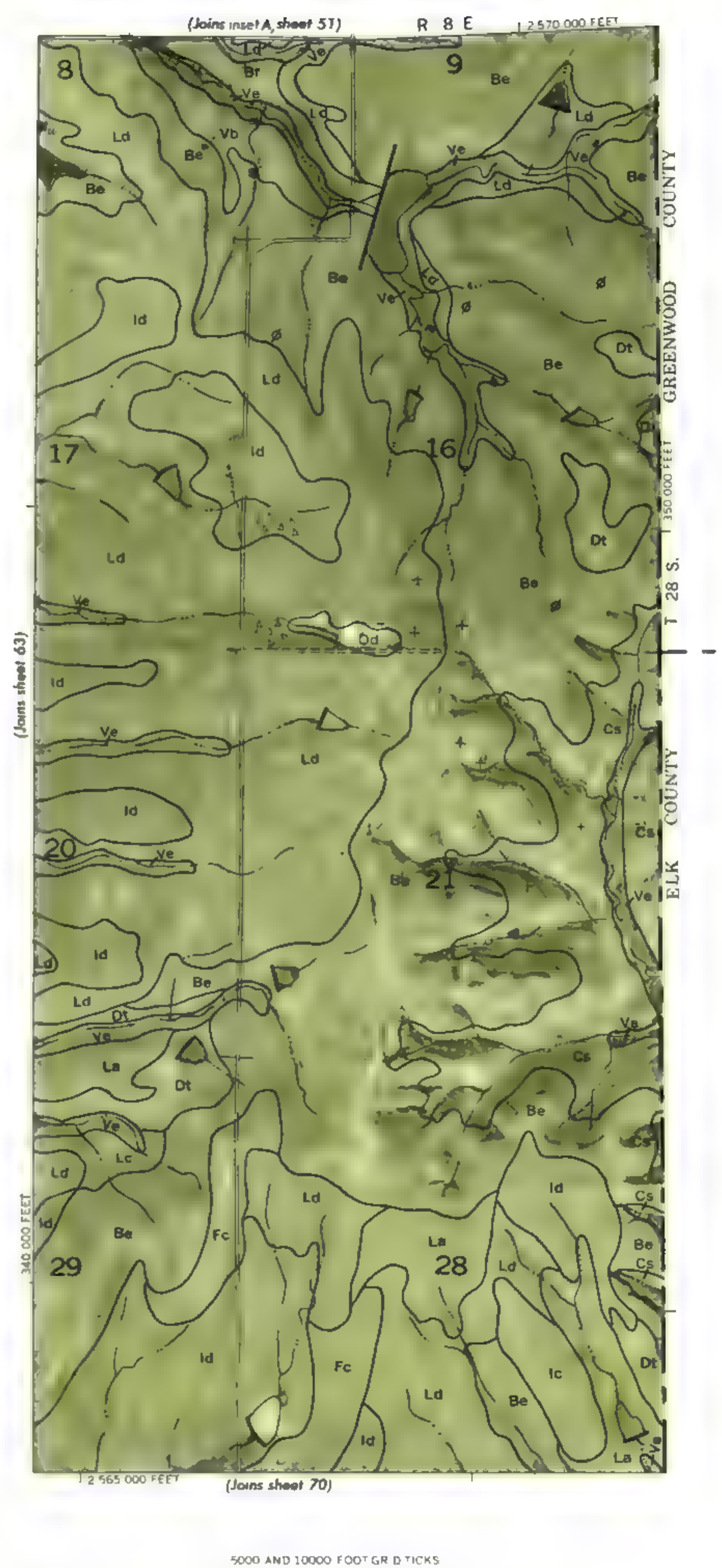
BUTLER COUNTY, KANSAS — SHEET NUMBER 70



INSET A



INSET B

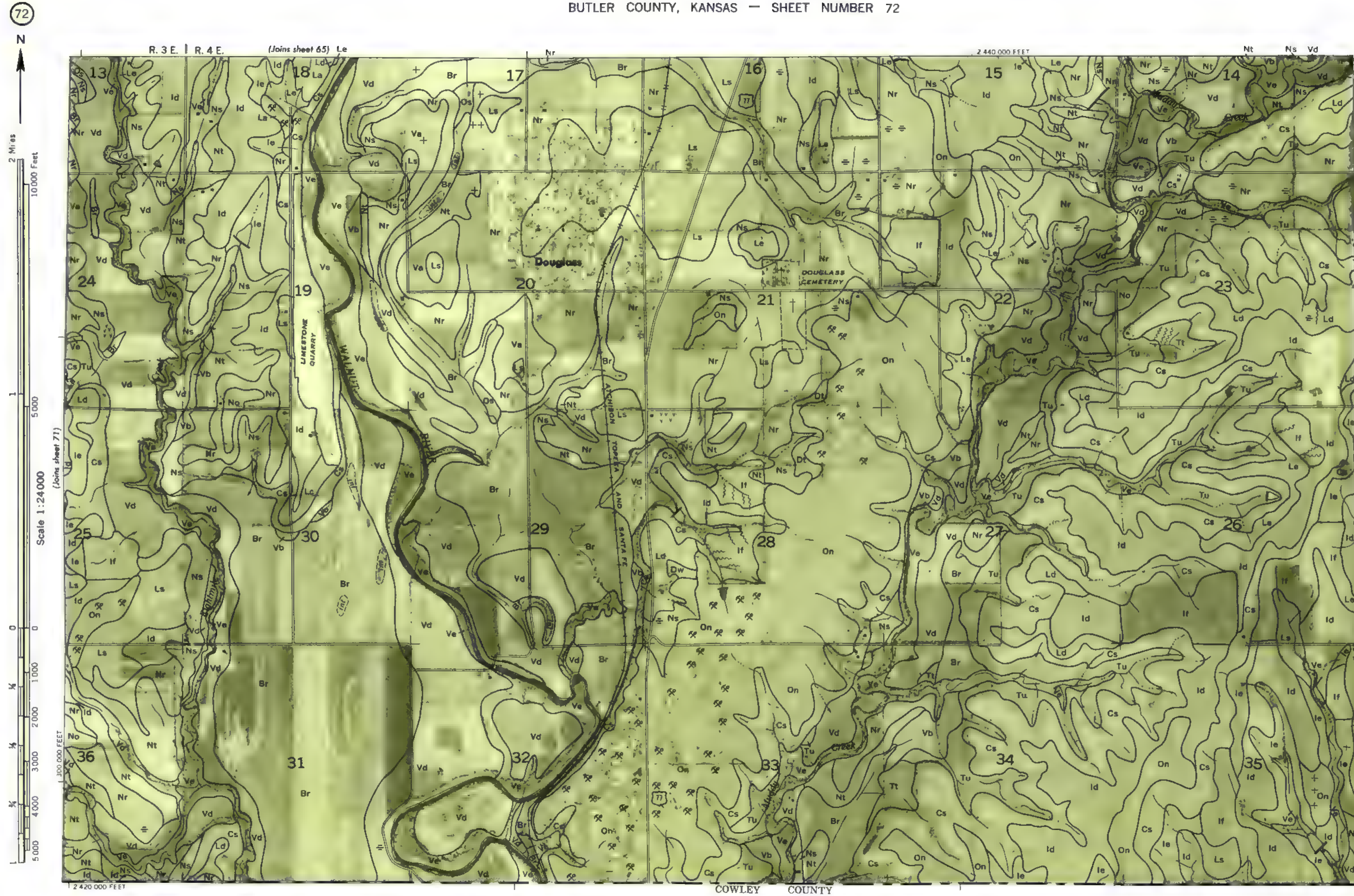


Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 10 000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station


R 3 E
(Joins sheet 64)
(Joins sheet 72)
T 29 S
SEDGWICK COUNTY
COWLEY COUNTY
N
Scale 1:24 000
2 Miles
10000 Feet
Richland School
Richland Cemetery
Polecat Creek
Dutch Creek
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36



Land division corners are approximately positioned on this map

Photobase from 1970 aerial photography. Positions of 10 000 foot grid ticks are approximate and based on the Kansas coordinate system, south zone

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station

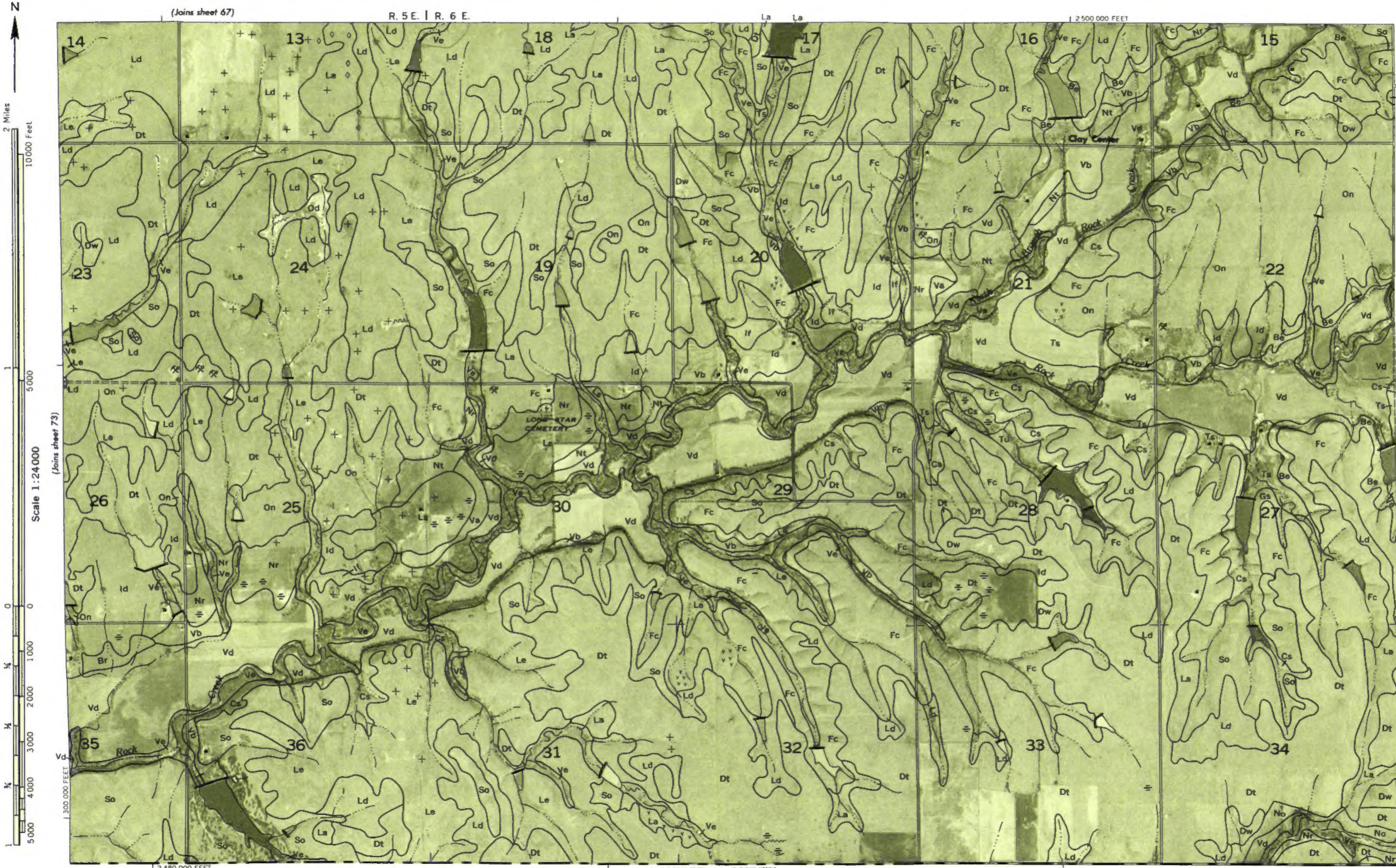
BUTLER COUNTY, KANSAS NO. 72

BUTLER COUNTY, KANSAS NO. 73

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

Land division corners are approximately positioned on this map.

BUTLER COUNTY, KANSAS — SHEET NUMBER 74

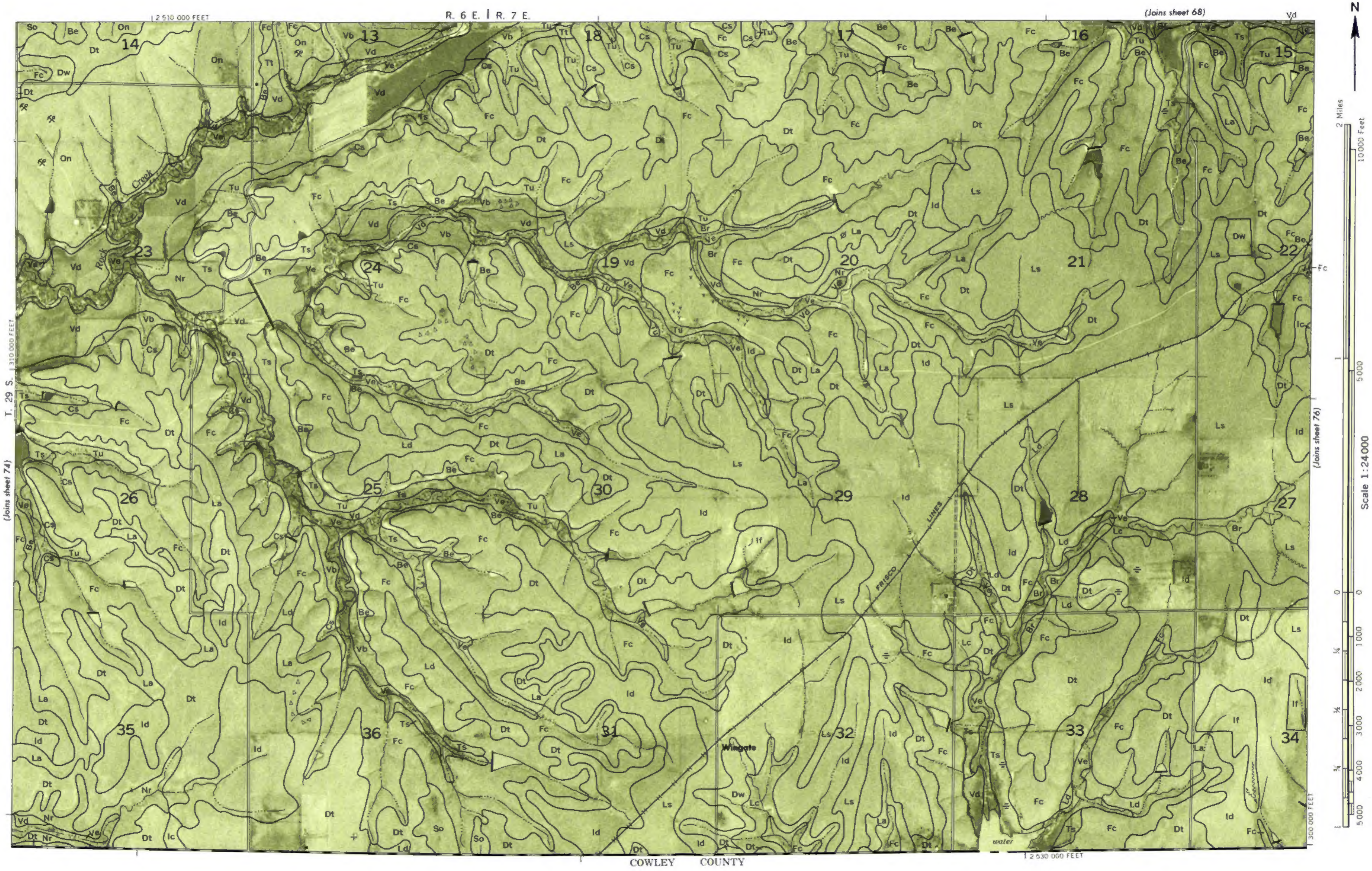


Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

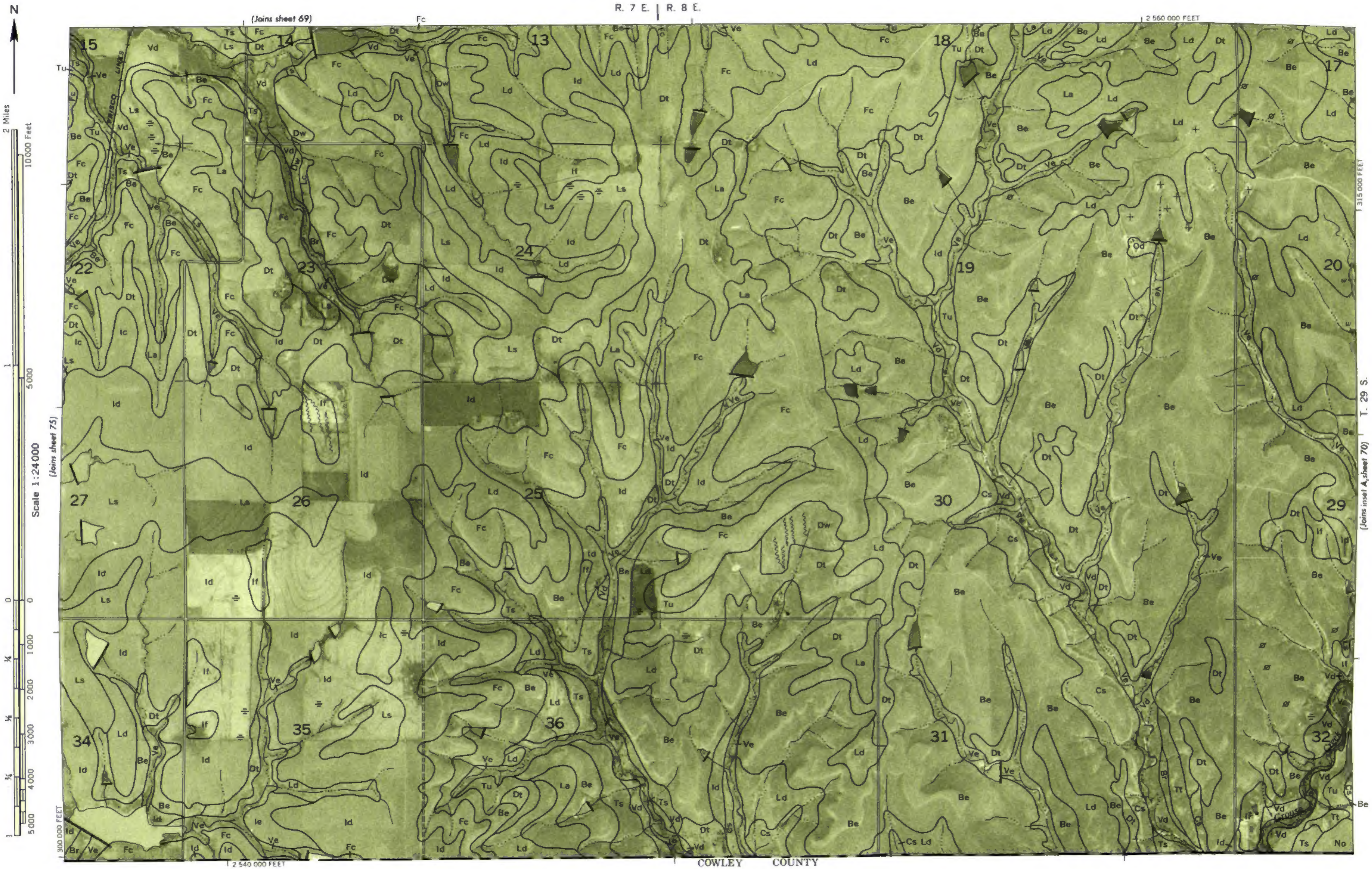
BUTLER COUNTY, KANSAS NO. 74



BUTLER COUNTY, KANSAS NO. 75

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station. Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone. Land division corners are approximately positioned on this map.

BUTLER COUNTY, KANSAS — SHEET NUMBER 76



5000 AND 10000-FOOT GRID TICKS

Land division corners are approximately positioned on this map.

Photobase from 1970 aerial photography. Positions of 10,000-foot grid ticks are approximate and based on the Kansas coordinate system, south zone.

This map is one of a set compiled in 1972 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Kansas Agricultural Experiment Station.

BUTLER COUNTY, KANSAS NO. 76